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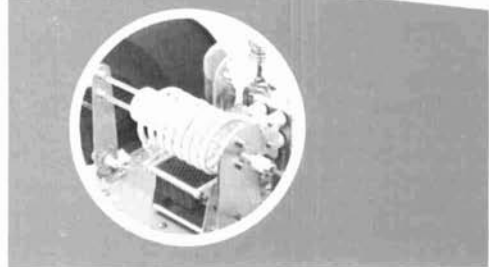
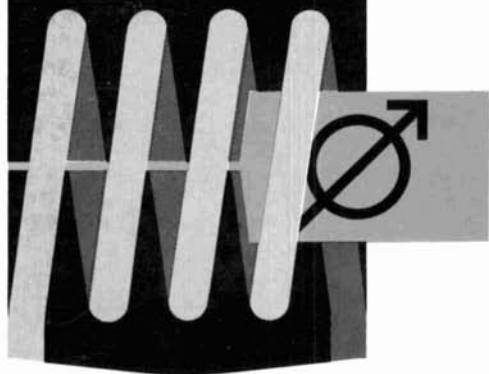
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# ham radio

magazine

JULY 1970

## INDUCTIVELY- TUNED HIGH- FREQUENCY TANK CIRCUIT



### *this month*

- solid-state receiver 10
- digital frequency counter 16
- two-meter kilowatt 26
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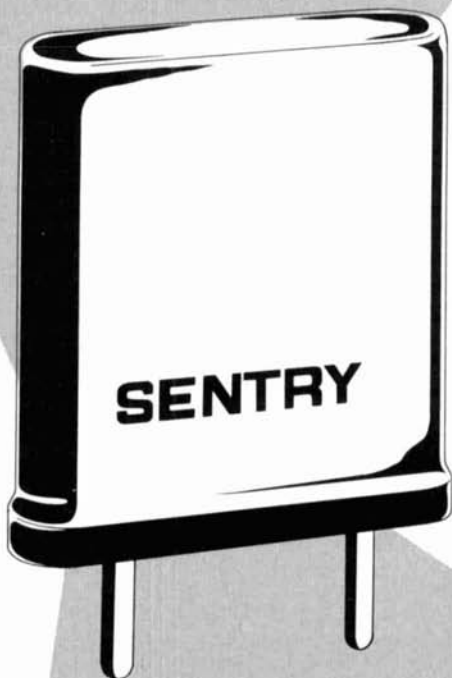


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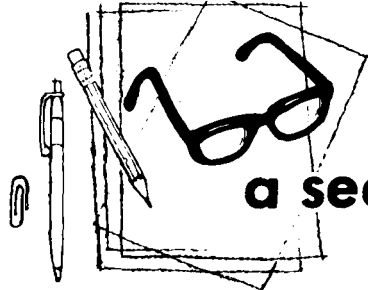
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## a second look by jim fisk

Do you remember the days when the upper frequency limit of transistors was limited to a few hundred kHz? The days when the basement experimenter would sort through a box of new transistors hoping to find at least one device that he could use in a 455 kHz i-f strip? Some semiconductor scientists even doubted that high-frequency transistors could be manufactured. Then Philco came out with the SB-100 surface-barrier transistor and *practical* high-frequency rf circuits started appearing in the magazines. After that came Fairchild's Planar process, and the gradual but major changeover from germanium to silicon. Since then improved manufacturing techniques have resulted in transistors with higher frequency capability, lower noise output and larger power dissipation than we could have imagined—and the end is not in sight.

Microwave power transistors, although still too expensive for amateur applications, have been available for some time. However, for the most part power levels have been limited to the milliwatt range. Power limits have been slowly creeping up though, and this summer Fairchild is expected to market *10-watt power transistors* for operation at *2000 MHz*. It is reported that they will also introduce some new low-noise small-signal devices with very high gain-bandwidth products.

Although not too many hams venture into the world of the super-high frequencies, IBM's research division in Switzerland has come up with a gallium-arsenide field-effect transistor that exhibits more than 3-dB gain at 17,000 MHz. From data gained in their laboratories it appears that the maximum oscillation frequency for this device may be as high as 30,000 MHz. This is at least 2½ times higher than any current models.

The new gallium-arsenide transistor is called a mesfet—metal semiconductor field effect transistor, and uses a Schottky barrier gate, rather than the more familiar insulated-gate arrangement. A rectifying contact is established directly at the metal-semiconductor's surface. A chromium-nickel-gold sandwich, 40 millionths of an inch wide and 8 thousandths of an inch in diameter, forms a circular gate that completely surrounds the circular-shaped drain.

From another part of the semiconductor world comes a microwave diode packaged in a 1N23 rectifier cartridge that produces peak powers of 1.2 kW at 1100 MHz. A result of work at RCA, the device actually consists of five avalanche diodes in series. Avalanche diodes use drift time, that old bugaboo of vacuum tubes, to generate microwave power. Bunched current carriers drift through the solid-state crystal of the diode and deliver rf power by causing an external circuit current 180° out of phase with the voltage. These diodes are often referred to as IMPATT devices (from IMPact Avalanche Transit Time), and are like klystrons in some respects since both use transit time and current-carrier bunching in their operation.

Because of high cost, it's doubtful that any of these devices will see widespread amateur use in the immediate future, but the nature of semiconductor manufacturing is such that as techniques improve, yields go up, and prices come down. Remember when a new CK722 audio transistor wiped out a ten-dollar bill? Today you can buy an equivalent device for 39¢—and if you're willing to take a chance, \$1 the bagful.

Jim Fisk, W1DTY  
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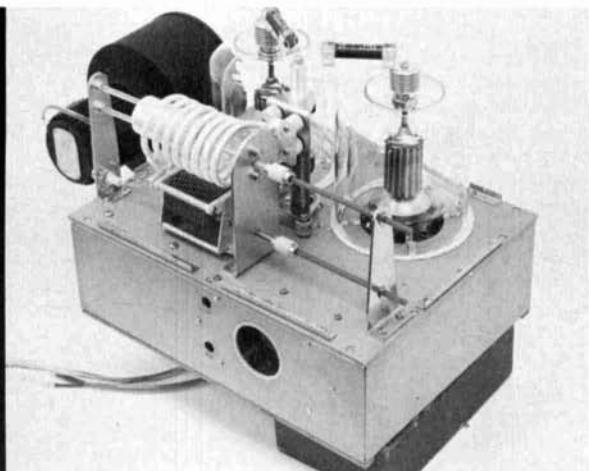
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## inductively-tuned high-frequency tank circuit

A method  
for achieving  
high efficiency in  
the "shadow region"  
between  
14 and 54 MHz

William I. Orr, W6SAI, Eimac Division of Varian

Radio frequency amplifiers require a certain critical value of plate circuit impedance and Q for optimum performance at any frequency. Design deviations may lead to higher levels of intermodulation distortion or excessive harmonic radiation. While the design requirement may be quite tolerant in some cases, the mechanical assembly of the components and the choice of proper values become increasingly critical as the operating frequency nears the upper region of the hf spectrum. It is as though a "shadow region" exists that's too high for conventional lumped circuit components, yet is too low for conventional vhf linear and stripline techniques. The "shadow region" extends roughly from 27 through 54 MHz.

Above 27 MHz or so, the construction of a conventional high-power plate-tuning circuit having good Q and good efficiency can be vexing, as residual tube and circuit capacitances combine to assume a major portion of the tank circuit capacitance. It's possible, in fact, for this residual



capacitance to be much larger than specified for proper design considerations. The unusually high circuit capacitance may lead to unreasonable  $Q$  and high circulating tank current, resulting in poor over-all efficiency and excessive heat loss in the tank circuit.

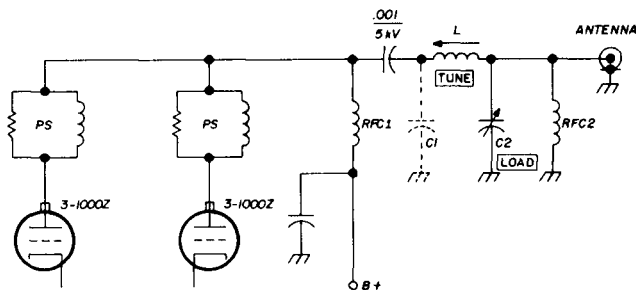
### inductive tuning

To achieve good circuit efficiency and proper  $Q$  in the upper portion of the hf spectrum, it is convenient to resort to a different mechanical configuration than is commonly used at lower frequencies. One way to overcome problems of efficiency and  $Q$  is to reduce residual circuit capacitance to an absolute minimum by re-

27 and 54 MHz. The plate tank is a conventional pi network, inductively tuned by a shorted turn within the plate coil. The turn (or "slug") is moved into and out of the coil by a lead screw driven from a counter dial mounted on the amplifier panel. Tank circuit values were derived from pi network charts.<sup>1</sup>

The amplifier uses a pair of parallel-connected 3-1000Z high- $\mu$  triodes in a grounded-grid, cathode-driven circuit with zener diode bias.<sup>2</sup> The combined output capacitance of the tubes is approximately 15 pF. Stray circuit capacitance from plate to ground is less than 10 pF, which provides a minimum input capacitance (C1) for the pi network of about 25pF.

fig. 1. Inductively tuned tank circuit using conventional component values. C1 is the residual circuit capacitance plus tube output capacitance. Resonance is achieved by a variable shorted turn moved inside L.



moving the cause of the largest portion of this unwanted capacitance: the tank tuning capacitor. Circuit resonance can then be established by including a fixed capacitance combined with a variable inductor.

The inductor can be a fixed, high- $Q$  coil having a low-loss shorted turn introduced into one end. As the turn is moved within the coil, coil inductance is reduced, and resonance is established by correctly positioning the shorted turn (fig. 1). The rf current in the shorted turn is high compared to the coil current; however, if the turn is of homogeneous structure and low-resistance material, turn losses will be small.

Shown in the photographs is a commercial 5-kW input PEP linear amplifier designed for any 500-kHz range between

Additional capacitance can be added for operation at lower frequencies. Ceramic or vacuum padding capacitors can be used for this purpose.

### construction

Tank-circuit inductance is calculated for the low-frequency end of the tuning range in the usual manner. As the shorted turn is driven into the plate inductor, its inductance decreases, and resonant frequency increases. A range of about 500 kHz or so can be obtained with this assembly.

Construction details are shown in fig. 2. The shorted turn is a section of seamless copper water pipe 1-3/4 inches O.D. by 3 inches long. Discs of insulating material are cut to fit into the ends of the pipe and are held in position with small pins or rivets. A

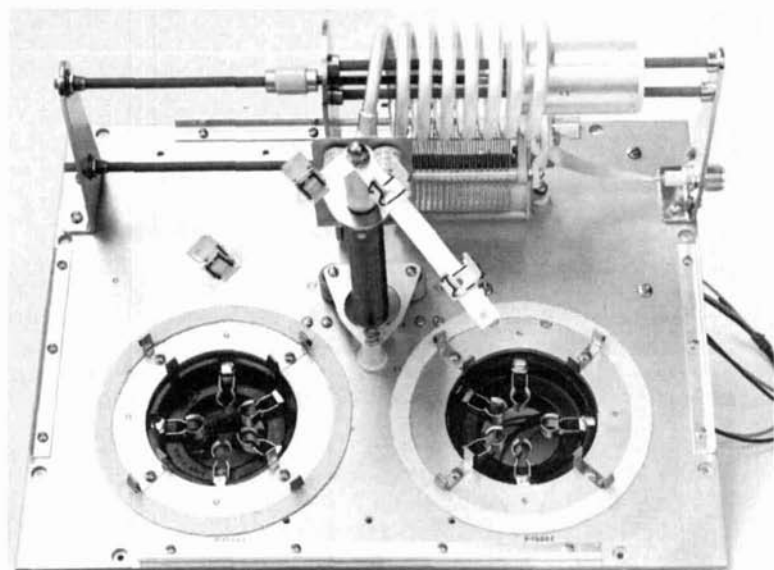


shorted turn is ungrounded at all times, and no moving parts carry rf current.

The plate tank coil is wound with ¼-inch-diameter silver plated copper tubing with an I.D. of 2-¼ inches, providing ample clearance for the shorted turn to move within the coil without danger of arcing. Heavy-duty copper mounting lugs are silver soldered to the coil. Resonance is initially established with a grid-dip oscillator. Indication of resonance is quite broad. Loading is accomplished with the pi network variable output capacitor, C2.

value will cause excessive fundamental rf power to dissipate in the parasitic resistor. The proper value of shunt inductance, while not particularly critical, should be determined for the operational range of the amplifier in each case.

The amplifier shown in the photographs was designed for commercial service and is included in a shielded cabinet as part of a larger package. A similar design using 4-1000A's has been built for commercial ssb service at the 6-kW PEP level—but that's another story. The basic design is



top view of the high-power commercial amplifier. Inductively tuned tank is shown at rear. Tuning is the same as with a variable capacitor, except inductance decreases as shorted turn penetrates coil. Parasitic suppressors have been removed for this photo.

### parasitic suppression

An important consideration in plate-circuit design is a parasitic suppressor. In this amplifier parasitic suppressors are included in each plate lead. Each suppressor is a 40-ohm, 16-watt *Glo-bar* resistor shunted across an inductor, which consists of a length of plate lead. The value of the shunt inductance is important. A too-small value won't completely suppress the tendency for vhf parasitics, and a too-large

adaptable to any high-power amplifier operating in the upper region of the hf spectrum.

### references

1. William I. Orr, "Pi and Pi-L Networks for Linear Amplifiers," *ham radio*, November, 1968, page 36.
2. William I. Orr, "The 3-500Z in Amateur Service," *ham radio*, March, 1968, page 56.

ham radio

# a versatile solid-state receiver

The answer  
to many receiver  
problems:  
a circuit  
featuring  
high selectivity  
for cw, ssb,  
and rtty

George W. Jones, W1PLJ, 12 Trail Street, Cambridge, Massachusetts 02138

With transistors in their present state of development, it hardly seems worthwhile to use vacuum tubes in receiver circuits. At one time it could be argued that cost was a factor, but things have changed. For example, the RCA 40673, a gate-protected dual-gate mosfet, costs about \$2.00. In a mixer circuit it will do the same job as a 6BE6, but with fewer components and less power. The mosfet costs a few cents more than the tube, but you can eliminate a screen dropping resistor, screen bypass capacitor, and tube socket, and a big power supply isn't required.

Several mosfet's are available at less than a dollar, such as the RCA 40468 (75c). Very few tubes can be obtained for this amount. For about \$4.00 you can buy not one, but *four* IC audio amplifiers in one package: the RCA CA3048. Are you convinced?

## system description

The solid-state receiver described in this article is used with the components shown in **fig. 1**. A recommended converter is described in reference 1. Typical circuits for the vfo, or local oscillator, appear in reference 2 and 3. The 80-meter tuner is described in reference 4.

## features

The solid-state receiver uses mosfet's in rf and mixer stages to reduce cross

modulation. IC's are used in the product detector and audio amplifier. A 9-MHz crystal filter is used for ssb reception. An additional crystal filter, operating at 2.215 MHz, with a 250-Hz bandwidth, provides passband tuning. This allows the i-f passband to be shifted a limited amount without changing the beat note of received signals. Another feature is that the i-f system provides reception over a 2.8-kHz bandwidth while allowing you to boost the one signal you're interested in.

the 2.215-MHz filter. The filter output is then converted up to 9 MHz and applied to the product detector.

The 11.215-MHz oscillator frequency is variable over a small range, so that any slice within the 9-MHz filter bandwidth can be passed through the 2.215-MHz filter. Varying the 11.215-MHz oscillator frequency doesn't change the beat note of any signal, because the same frequency is fed to both mixers. Thus it's easier to keep track of the signal you're trying to receive.

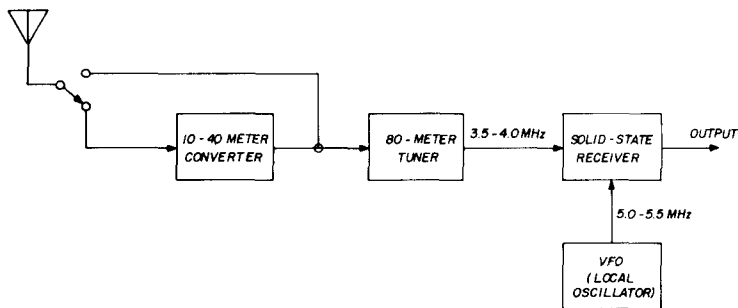


fig. 1. Integrated receiving system for high performance and versatility. Recommended circuits for the converter, 80-meter tuner, and vfo are given in the references.

## operation

A block diagram of the solid-state receiver appears in fig. 2. Output from the 80-meter tuner, 3.5-4.0 MHz, is mixed with the vfo signal, 5.5-5.0 MHz, to produce a 9-MHz difference signal. This is applied to the crystal filter. If the entire 2.8-kHz bandwidth of this filter is desired, 9-MHz i-f amplifier gain is increased. This allows you to hear what's going on within 2.8 kHz when listening for cw stations, or allows audio components to come through when receiving ssb.

## selectivity

If you wish to listen to only one cw signal in interference, the 9-MHz i-f gain is turned down, and the gain of the two mixers on each side of the 2.215-MHz filter is turned up. The 11.215-MHz oscillator is turned on and tuned so that the desired signal is converted down to a frequency that's within the passband of

## detector

The 9-MHz signal, from either the 9-MHz i-f amplifier or from the second mixer in the 2.215-MHz filter system, or both, now reaches the product detector. Here it's mixed with the output of a crystal oscillator operating at 9.0015, 8.9985, or 8.99745 MHz. The first two frequencies allow sideband selection on ssb, and the third allows standard tones of 2125 and 2975 Hz to be obtained from an RTTY signal centered in the 9-MHz filter's passband. Product detector output is then applied to an IC op amp, in which most of the receiver's gain is produced.

## af amplifier

With most of the system gain developed in the af stage, cross modulation is minimized because the rf signals are at low level in the preceding stages. The af amplifier will drive a pair of crystal headphones; however, a power amplifier

is required if you want to use a speaker.

The af stage drives a one-stage amplifier, whose output is rectified to provide amplified agc. This stage's output also drives an S meter through an emitter follower.

the presence of strong signals. Automatic gain control is also applied to the mixer, and a diode gate passes the appropriate signal to control stage gain.

Mixer output is coupled through a tuned circuit to a McCoy 48B1 crystal

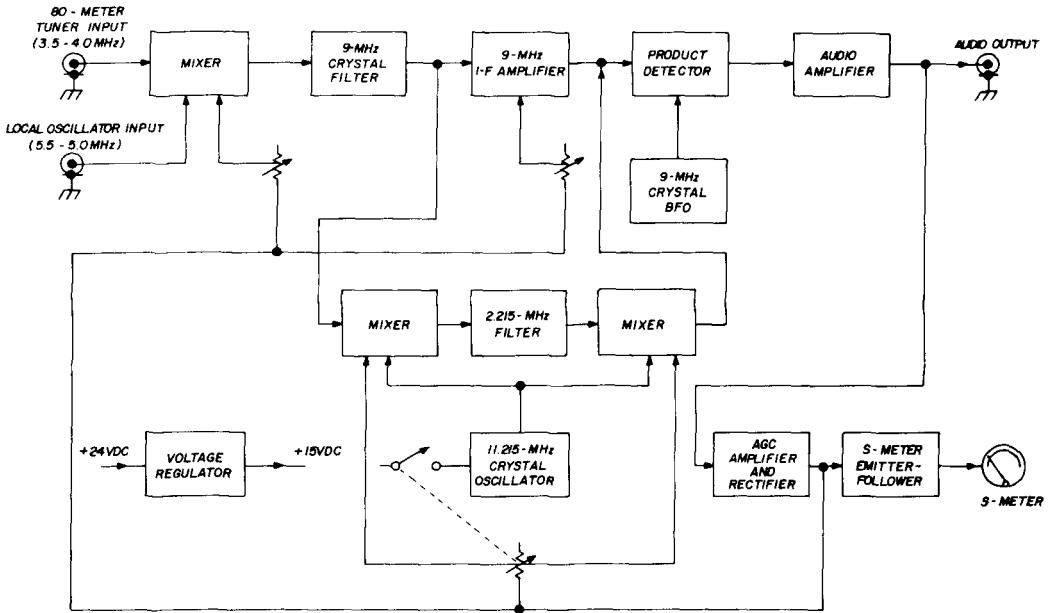


fig. 2. Functional block diagram. Filter and oscillator frequencies are nominal; see text.

Power is obtained from unregulated positive and negative 24-volt supplies. A simple 15-volt regulator supplies power for the fet's and ICs.

### the circuits

The first mixer, input tuned circuit, and i-f system are shown in fig. 3. An rf amplifier isn't used, because the mixer gives adequate sensitivity for either 80-meter operation direct from the antenna, or from other bands with a converter. Omitting an rf amplifier reduces cross modulation from strong signals by keeping input-signal gain low preceding the filter. The input circuit is from a solid-state receiver that appeared in another article.<sup>5</sup>

### mixers

A manual gain control reduces gain in

filter. Although the Miller 1740 and 1741 transformers have two windings, I obtained more gain by using only one winding as shown; probably because the windings are loosely coupled. Filter output is coupled to the i-f amplifier, and the otherwise unused output coil winding is used to neutralize the stage. Neutralization is necessary to reduce feedthrough when stage gain is reduced and the narrowband section is used.

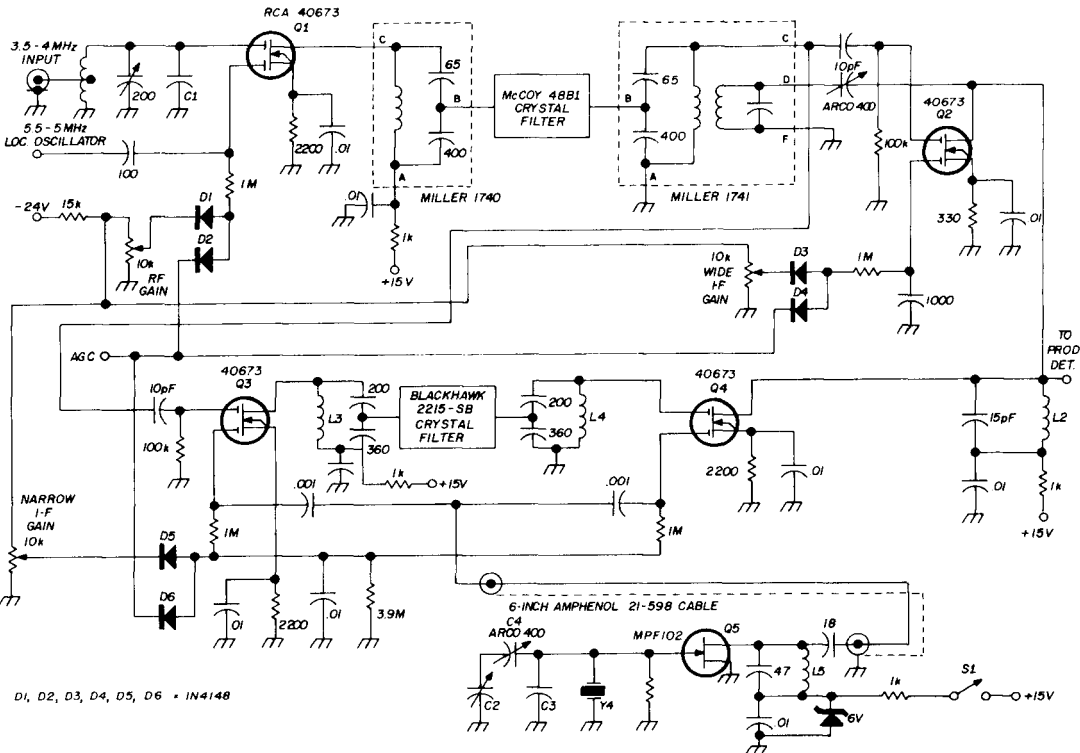
Mixer Q3 converts the 9-MHz i-f signal to 2.215 MHz, which is passed through the narrowband filter. Mixer Q4 then converts whatever signal manages to get through the filter to 9 MHz, which is applied to the product detector. Since both mixers use a common oscillator, the frequency that comes out of Q4 is the same as that which went into Q3; there-

fore, if the signal can be heard at all, it's beat note is the same regardless of which i-f went through or the tuning of the 11.215-MHz oscillator.

The tuning of the 11.215-MHz oscillator determines what portion of the wide

MHz, because 9002 kHz won't pass through both filters. Therefore, the oscillator must cover 11.2136 to 11.2164 MHz and no more.

A variable capacitor across the crystal varies its frequency over this narrow



- |        |   |        |  |
|--------|---|--------|--|
| C1, C2 | 100 pF (Hammarlund HF-100)                                  | L2     | 28 microhenries (CTC 2060-4)   |
| C3     | 5 pF must be chosen for individual crystal (see Text)       | L3, L4 | 63 microhenries (CTC 2060-6)   |
| L1     | 23 turns Airdux 632-T, tap at 1½ turns, 32 tpi, ¾" diameter | L5     | 15 turns no. 22 wire on 3/8" diameter slug-tuned form (CTC 1534-2-2) |
|        |   | Y4     | 11.215 MHz crystal   |

fig. 3. Rf and i-f circuits. Features include low intermodulation products and passband i-f tuning for cw.

filter's passband goes through the narrow system. To get reasonable sensitivity and make best use of the filters, it's necessary that a slice within the wide filter's passband be converted to the frequency of the narrow filter. The wide filter passes frequencies between 8998.6 and 9001.4 kHz. It will do no good to convert a frequency of, say, 9002 kHz to 2.215

range. C2 is a front-panel control for moving the passband, and C3 and C4 limit the variation so that C2's tuning will be less critical. Some experimentation will be needed to arrive at the correct values for C3 and C4.

The six-inch length of shielded wire could have been avoided with better layout. No trouble has been experienced





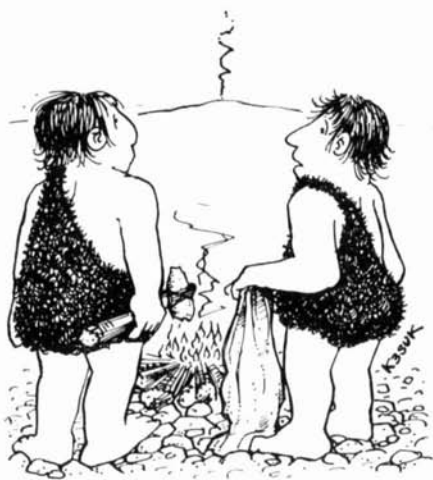
external adapter.

The audio amplifier IC output is applied to agc amplifier, Q8. The agc amplifier is operated without bias so that no output is obtained until the input exceeds 0.6 volt peak, enough to turn on the transistor. Once this threshold is reached, very little additional voltage is needed to get full output from the agc rectifier. This results in a very flat agc characteristic. Some trouble was experienced with motorboating in the agc, which was cured by reducing Q8's gain with the 220-ohm resistor in the emitter lead.

Q9 drives the S meter. S-meter sensitivity can be increased either by decreasing the resistance in series with the meter or by increasing the value of the 3.3-meg resistor, so that more agc voltage must be produced for a given amount of gain reduction.

A diode gate supplies either the agc voltage or a muting voltage from an external source to the agc line. A negative muting voltage is needed while transmitting, and the resistors associated with the muting voltage depend on the voltage available.

Q10 and Q11 comprise a simple regulated 15-volt power supply for the fet's and IC's.



"Ten minutes ago he was 40 over 9 . . .  
then he went down in the mud."

## performance

Performance is excellent. Using the wide i-f alone, a signal-to-noise ratio of 20 dB was obtained with 1-microvolt input from a Knight KG-686 signal generator. Using the narrow i-f alone, a 16-dB signal-to-noise ratio was obtained with the attenuator on the signal generator at zero. Avc threshold is reached with 10 microvolts input, at which point output is 0.95 volt for a typical setting of controls. Increasing the input to 100 millivolts, an 80-dB increase, only raises the output to 2.1 volts, a 7-dB increase.

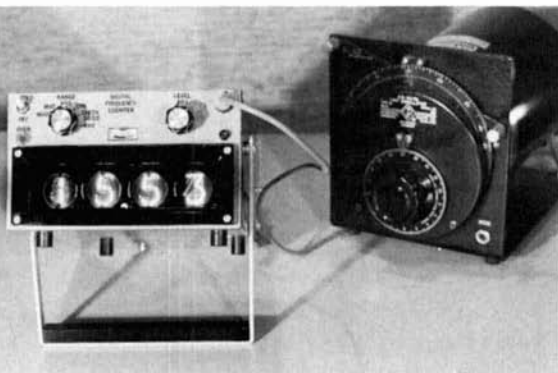
Future plans for the receiver include a general-coverage converter using a phase-locked oscillator so that any multiple of 500 kHz can be used as a mixer frequency, with a panadapter operating from the output of the first mixer or possibly from a separate first mixer.

## references

1. M. Goldstein, VE3GFN, "Bandswitching FET Converters," *ham radio*, July, 1968, p. 6.
2. J. Fisk, W1DTY, "Stable Transistor VFO's," *ham radio*, June, 1968, p. 14.
3. G. Hanchett, W2YM, "The Field-Effect Transistor as a Stable VFO Element," *QST*, December, 1966, p. 11.
4. M. Goldstein, VE3GFN, and G. Cousins, VE1TG, "High-Quality Hybrid Receiver," *QST*, February, 1968, p. 42.
5. G. Daughters, WB6AIG, et al., "Solid-State Receiver Design with the MOS Transistor," *QST*, April, 1967, p. 11, and May, 1967, p. 22.
6. D. DeMaw, W1CER, "Some Notes on Solid-State Product Detectors," *QST*, April, 1969, p. 30.

ham radio





## compact frequency counter

A solid-state  
instrument  
featuring direct  
numerical readout  
to eight digits  
with four  
readout tubes

This digital frequency counter is an improved version of a design that appeared in an earlier issue of *ham radio* magazine.<sup>1</sup> The new design features direct numerical readout (using Nixie tubes), smaller size, simpler construction, and some optional circuits for increased versatility.

Two counter modules are presented. One, using five IC flip-flops, has a nominal upper counting range of 16-17 MHz. The other has a nominal upper range of 12-13 MHz, but uses only two ICs. The simpler construction and lower cost of the latter module should appeal to those with measurement requirements limited to this lower range.

An optional overrange indicator provides a visual warning when the count is higher than that indicated by the readout tubes. Switching logic is designed so that frequencies with as many as eight digits can be displayed using only four tubes.

With many new ICs appearing on the market, the Motorola devices used in this instrument continue to be the lowest priced, and their performance exceeds published specifications. They are truly a best buy for the amateur interested in building fine test equipment at lowest cost.

The B-6091 Nixie readout tubes were a lucky surplus buy; however, other types of readout tubes can be used as long as

Bert Kelley, K4EEU, 2307 South Clark Avenue, Tampa, Florida 33609

they're not biquinary. Be sure to obtain a data sheet with current-limiting resistor values and pin connections. It shouldn't be necessary to increase supply voltage above 170 volts, nor is it recommended.

In the design of this counter, I used information from Motorola applications bulletins, experience from previous designs,<sup>1</sup> and suggestions from other amateurs. W2FLJ suggested the 4-MHz clock, and W4IGX helped with the mechanical layout.

A block diagram of the basic instrument appears in **fig. 1**. All modules including the power supply are constructed on PC boards.\* The entire unit is enclosed in a 4x7x12-inch Minibox.

### clock module

This circuit (**fig. 2**) determines overall system accuracy. A highly stable crystal, as described by Hoff,<sup>2</sup> is used as a standard. The basic frequency is 4 MHz, which is divided twice to 1 MHz, then divided down by a series of decade dividers to 1 Hz. Five different time bases are used. For each time base, the clock generates a short pulse timed to occur prior to the negative-going transition of the main clock pulse. These advanced pulses, as well as the clock pulses, are selected by a range switch (**fig. 7**) and routed to the control module (**fig. 5**) for processing and use. Range switch contacts also ground NE-2 "decimal-point" bulbs positioned between the Nixies.

The crystal, an International HA-1,

provides frequency stability without an oven. The circuit will oscillate to 10 MHz and will remain within 1 Hz of WWV at 10 MHz if the specified crystal is used and the simple instructions in Hoff's article<sup>2</sup> concerning temperature compensation are followed.

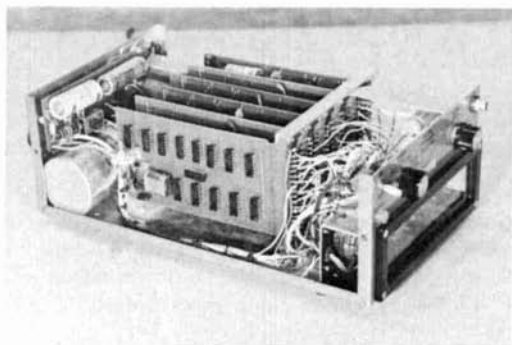
If you plan to build this counter, a 100-kHz crystal should not be used. The inherent accuracy of digital counters is determined by the quality of crystal time base. Most 100-kHz crystals will drift to the extent that at 10 MHz or so readings will be inaccurate, since frequency drift is multiplied by a factor of 100. Time bases using the 60-Hz line frequency have similar problems, and in addition don't lend themselves to the range switching system used in this instrument.

### 17-MHz counter module

Note that in the beginning of this article I mentioned that the *nominal* upper counting range of the counter module was 16-17 MHz. The maximum upper counting range depends on several factors: the JK flip-flops, skill of the builder, and even luck to a certain extent. If reasonable care is used in construction, the module should count to 17 MHz.

This module (**fig. 3**) uses five flip-flops in a ring counter, as described in reference 3. The ring counter is decoded by three MC724P dual quad input gates that drive 2N1893 high-voltage transistors. These ground the appropriate pin of the readout tubes. An MC799P satisfies loading and polarity requirements.

When completed, the counter should be checked with a conditioned pulse, such as the 1 Hz output from the clock. It probably will be necessary to reset the JKs with a 4-V pulse on the reset bus (by briefly shorting pins 1 and 2 of the counter decade under test). With all voltages applied, the Nixies should advance through 1-2-3 etc., to zero and start



Interior view of the frequency counter showing the clock module crystal and zeroing capacitor.

\*Printed circuit boards are available from Stafford Electronics, 427 So. Benbow Road, Greensboro, N. C. 27401. Kits, including boards and all components, are also available. A set of full-size layout drawings for the boards is available from *ham radio* magazine for 75¢.

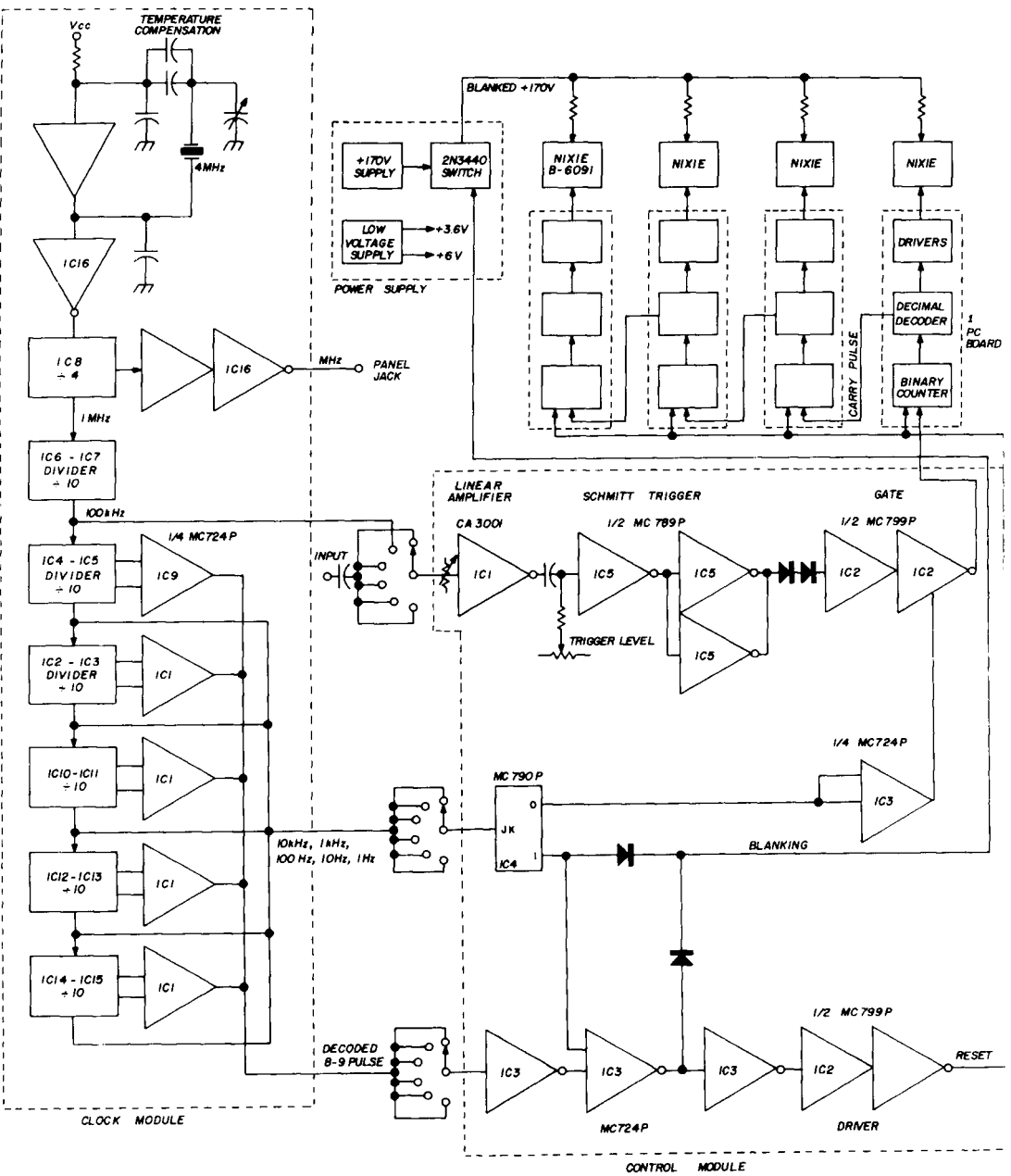


fig. 1. Block diagram of basic instrument. The "decoded 8-9 pulse" is an advance pulse that resets the count over again.

If the decade hangs up on a number, or more than one number lights, the work starts. Reference to the IC truth tables and other published information<sup>4</sup> should help to locate the defect.

The counter module shown in fig. 4 uses two of the latest Motorola RTL ICs,

the MC780P flip-flop and its companion decoder, the MC770P.\* The MC780P contains four internally connected flip-flops, with four outputs for decoding and the usual toggle and reset inputs. In

\*Listed in Allied's industrial catalogue supplement 692. The MC780P and MC770P sell for \$4.05 and \$3.55 respectively.

addition, four direct set inputs can be used to set the IC to any status—a feature not needed for a frequency counter, but useful for digital clocks.

Since this combination simplified construction and reduced cost, I obtained a supply of these ICs and built decades to check their performance. I found the

MC780/770P combination was not, and performance might vary slightly with other units.

I made some checks to determine if decade/decoder combinations could be intermixed within the same counter module. I found them to be incompatible because of different carry-pulse polarities.

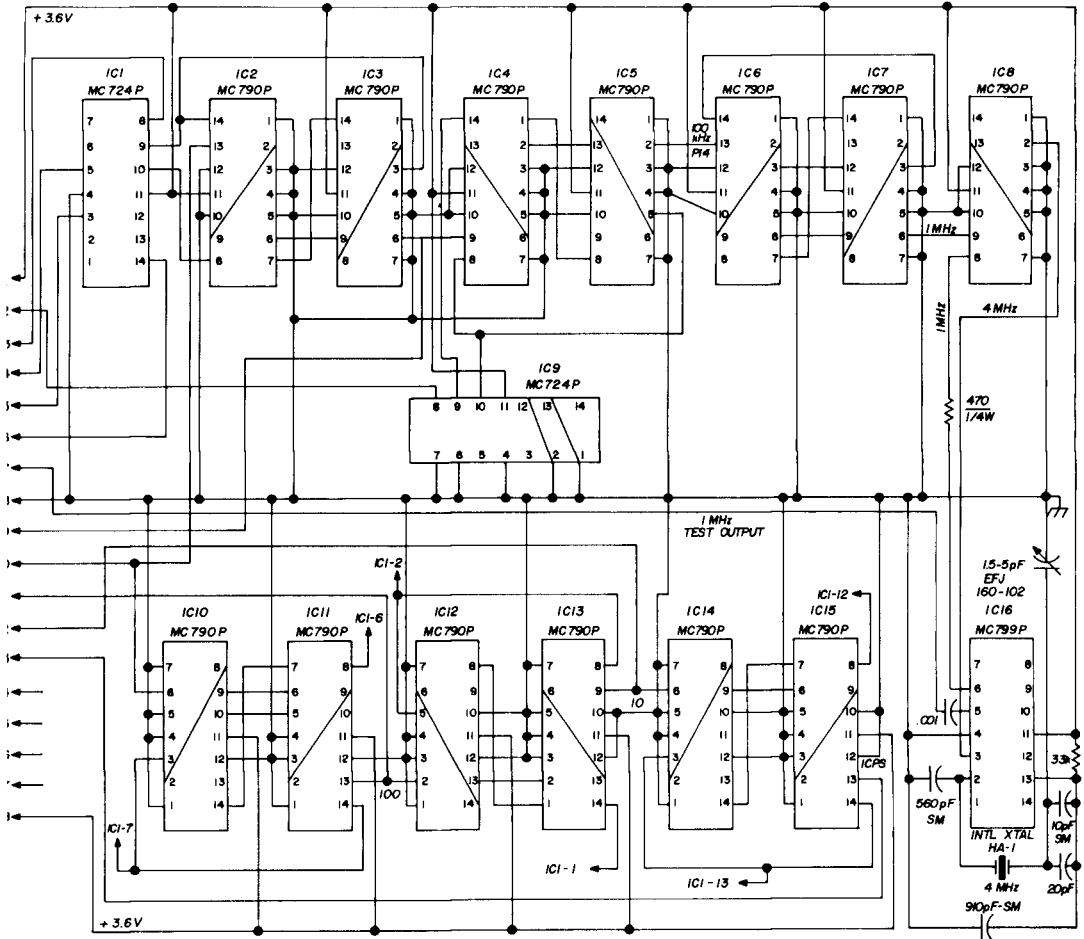


fig. 2. Clock module. Circuit provides outstanding frequency stability without an oven.

maximum reliable count frequency to be between 12 and 13 MHz. The more complex ring counter consistently counted to 16 or 17 MHz without special selection of components. Although the ring counter was checked with several decade-decoder combinations, the

However, they operated the overrange indicator properly, and no problems should occur if four similar decade/decoder combinations are used in the same counter module.

If you are satisfied with a top frequency of 12 MHz, this new counter design

with the two special ICs will greatly simplify construction and reduce cost.

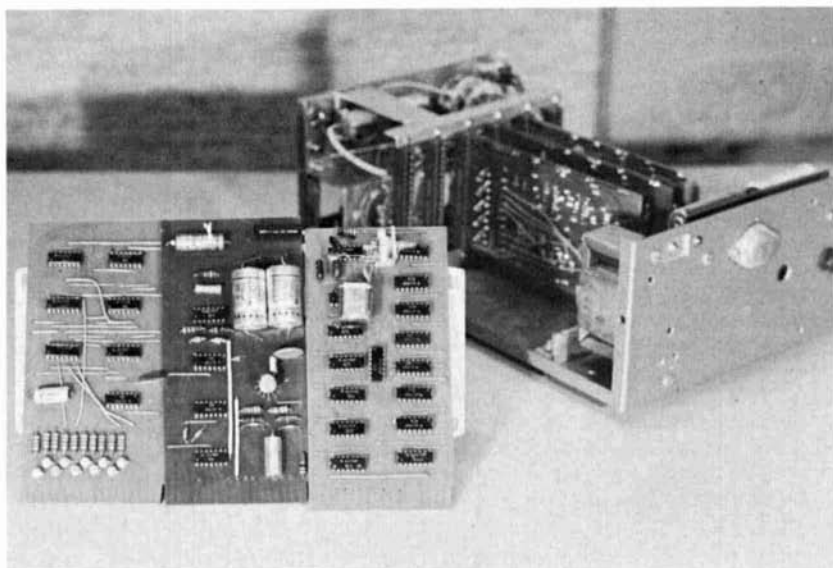
### control module

A linear integrated circuit amplifier, the CA-3001, results in a simple control module design (fig. 5). The CA-3001 has good response to at least 20 MHz. It has two outputs, only one of which is used, and a built-in gain control provision at pin 2, which offers a smooth, non-frequency-sensitive method of controlling circuit gain. I tried this method of con-

should be near 0.65V. Unsatisfactory diodes will vary widely. A similar test may be made for D1 and D2 by testing for a junction drop of 0.25V. Many diodes won't pass this test, and many junkbox diodes assumed to be germanium will turn out to be silicon. Of course, new diodes obtained from a reputable manufacturer won't require this test.

### logic and timing

Referring to figs. 1 and 5, IC2 operates as a combination driver and gate by using



Printed circuit boards used in the counter: left to right, counter module, control module and clock module. Four counter modules in the counter are identical.

trolling level, but the direct potentiometer approach offered better protection for high-input levels.

The MC789P Schmitt trigger shapes and limits the incoming signal, and diodes D3, D4 translate the dc level between MC789P and MC799P, acting as a form of zener. Junkbox silicon diodes may be used if they pass a simple test: connect the diode under test in series with a 1k resistor and monitor the voltage across the diode while the output from a power supply across the combination is varied from 0 to 10V. The diode voltage drop

IC3-14 as a switch to pull an internal element of IC2 to ground when inhibiting the count. If an unprocessed count pulse were applied to pins 13, 14 of IC3, the gate would open for only half the required time.

Pulses from the tens decades in the clock module are not symmetrical. IC4 restores pulse symmetry and delivers two voltages of opposite polarity and equal amplitude.

If a 1-Hz gate time is selected by the range switch, the following events occur (see the timing diagram, fig. 6): the

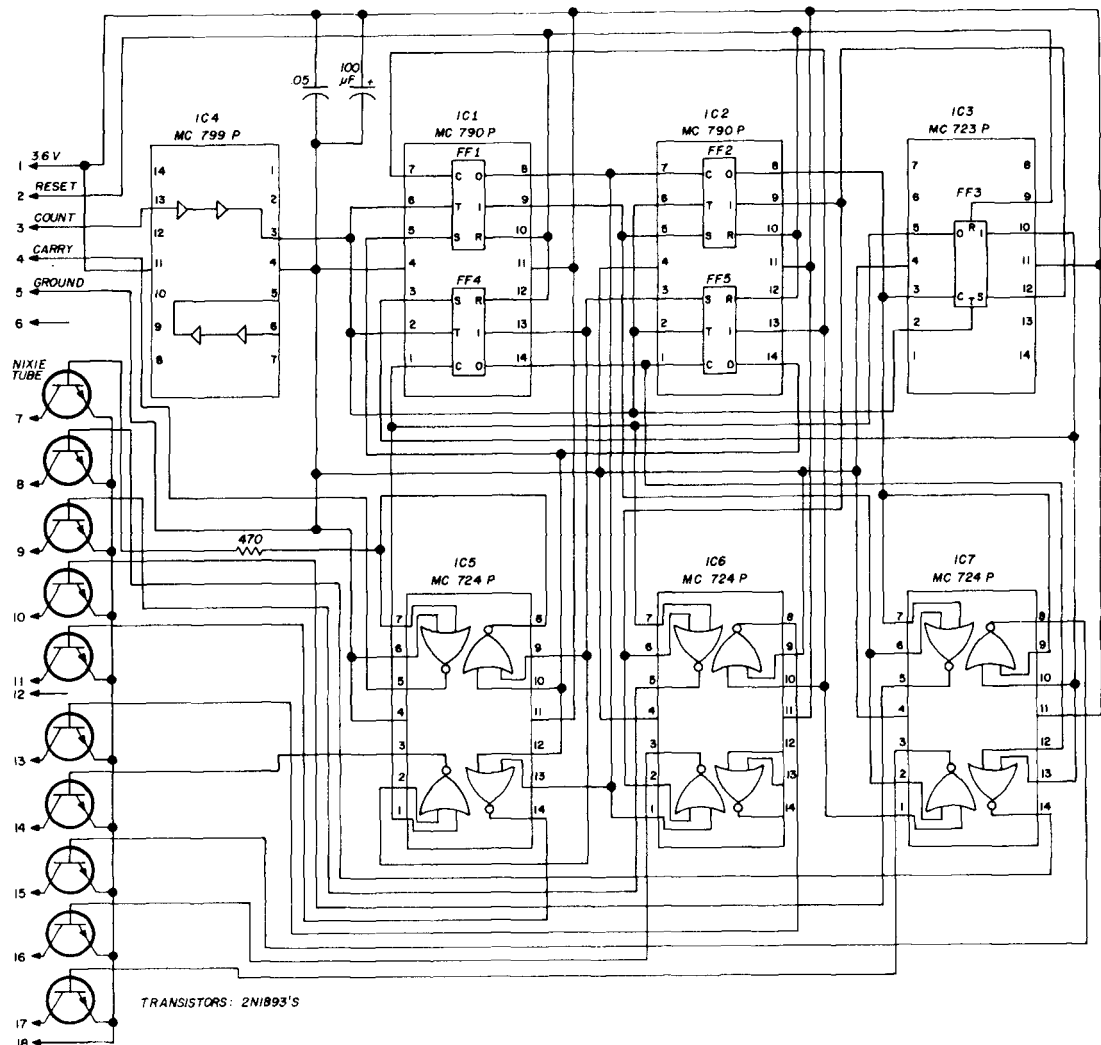


fig. 3. Basic counter module. Ring circuit provides nominal upper counting range of 17 MHz.

output from IC4 occurs at a 0.5-Hz rate. IC4-8 is positive for one second; IC4-9 is positive for one second, then its output falls to zero, allowing a count pulse to pass through IC2-5.

### to the counter decades

If IC4-9 output is low, IC4-8 is positive approximately 1.4 V, saturating one-half of a gate section connected to IC3-7. Diode D1 then conducts, which places a positive voltage on the blanking line at pin 15 on the module and the power supply, where it shuts off the 2N3440

high-voltage switch that controls power for the readout tubes.

If IC3-7 is saturated, the gate won't pass the advanced clock pulse; but when the next negative-going transition of the clock arrives, the JK reverses state and shuts off the count: the blanking voltage via D1 goes to zero, and the readout tubes light, displaying the count. At the same time the voltage will have dropped on IC3-7, and it will be ready to pass the next advanced pulse, which occurs near the end of the display interval.

When the advanced pulse arrives, it is

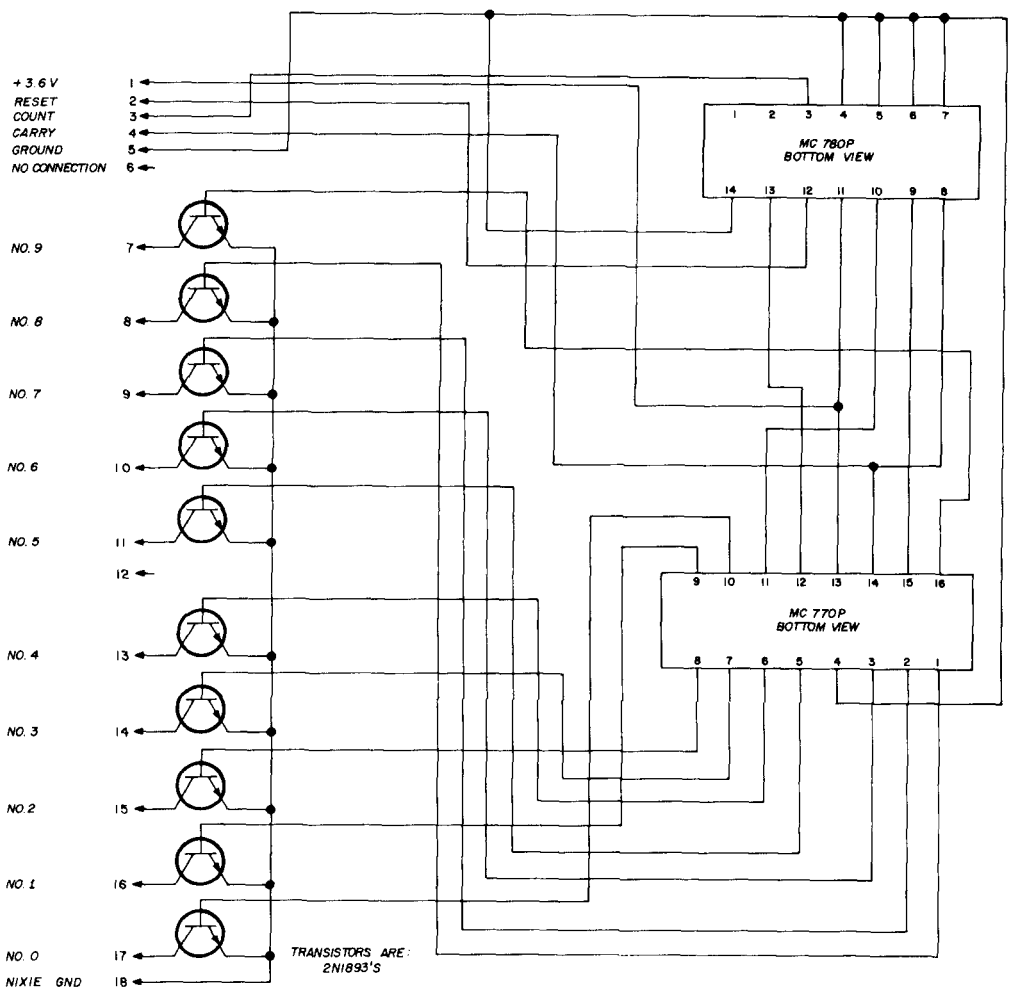


fig. 4. Alternate counter module using IC's that became available after completion of basic circuit.

inverted, gated, and allowed to reset the counters to zero. D2 conducts and shuts off the Nixie power so that when the next clock pulse arrives, the counters are cleared, the Nixies are off, and the JK changes state. D1 picks up the positive voltage on IC4-8 so that blanking remains off during the new count interval. This entire process takes place at speeds from 1 to 10,000 times per second, depending on the setting of the range switch.

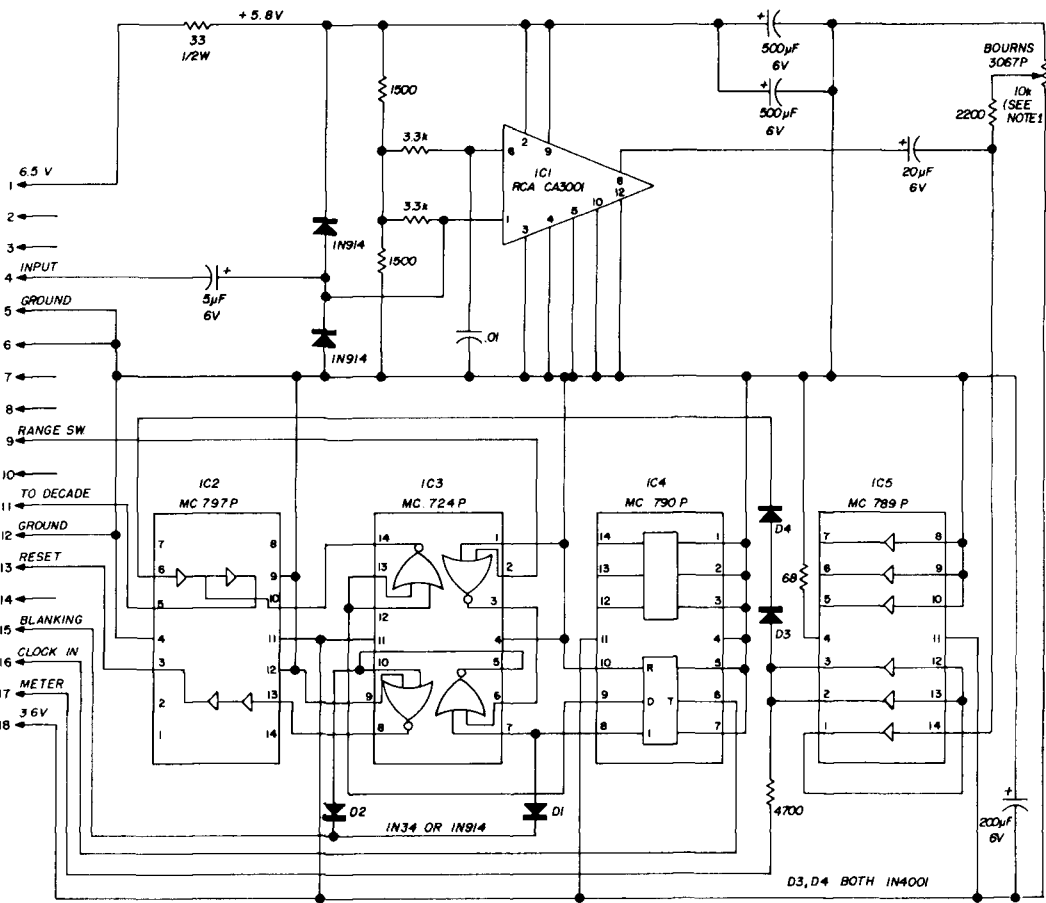
Some blinking will occur at the two lowest speed-count settings, but the display will be continuous at the other three speeds. It is possible to eliminate the blinking by the use of storage. Blinking is

not objectionable; therefore storage was not used.

### overrange display

It is possible to measure a signal with a frequency much greater than four digits by sampling the incoming signal at a fast rate. As mentioned previously, gate times as fast as 10,000 counts per second are used. If the incoming signal happens to be, say, 11,234,200 Hz and the gate is open at the fastest rate, then 1123 would register on the readout tubes—the last four digits would be dropped. If "decimal points" are connected to proper contacts on the range switch (fig. 7), the reading





**NOTES:**

1. PRESET AT MIDRANGE. AT FINAL ADJUSTMENT, ALTERNATELY ADJUST INPUT LEVEL AND THE 10k POT FOR MAXIMUM (15 TO 17 MHz), THEN LEAVE AT THAT POSITION.
2. OBSERVE DIODE POLARITY. THE END WITH THE BANDS IS THE CATHODE.

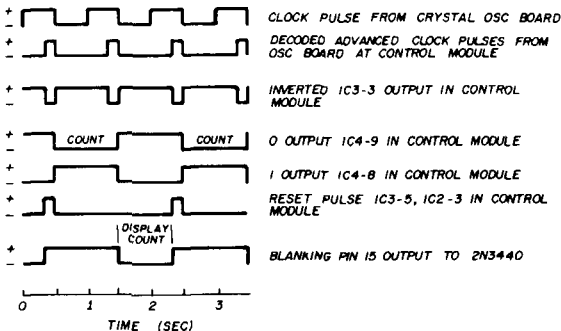
**fig. 5. Control module. The CA-3001 input amplifier has a response to 29 MHz.**

will be directly converted to MHz or kHz, eliminating mental arithmetic.

Now, if the range switch is rotated to the 1-Hz sampling rate, the remaining

four digits will be indicated, with the counter now reading 4200. (The excess count would have spilled out of the left hand decade in the form of carry pulses, lighting the overrange indicator.)

**fig. 6. Timing of control-module pulses.**



In counting and resetting, all digits on each Nixie are activated, but are permitted to light only during the display period by a blanking circuit, which rapidly switches the power to the Nixies. Thus, the readout tubes are strobed at the same frequency as the gate, and the count appears to stand still.

The overrange indicator (fig. 8) activates a neon light when the count is higher than that indicated by the readout tubes. The MC723P toggles on the first

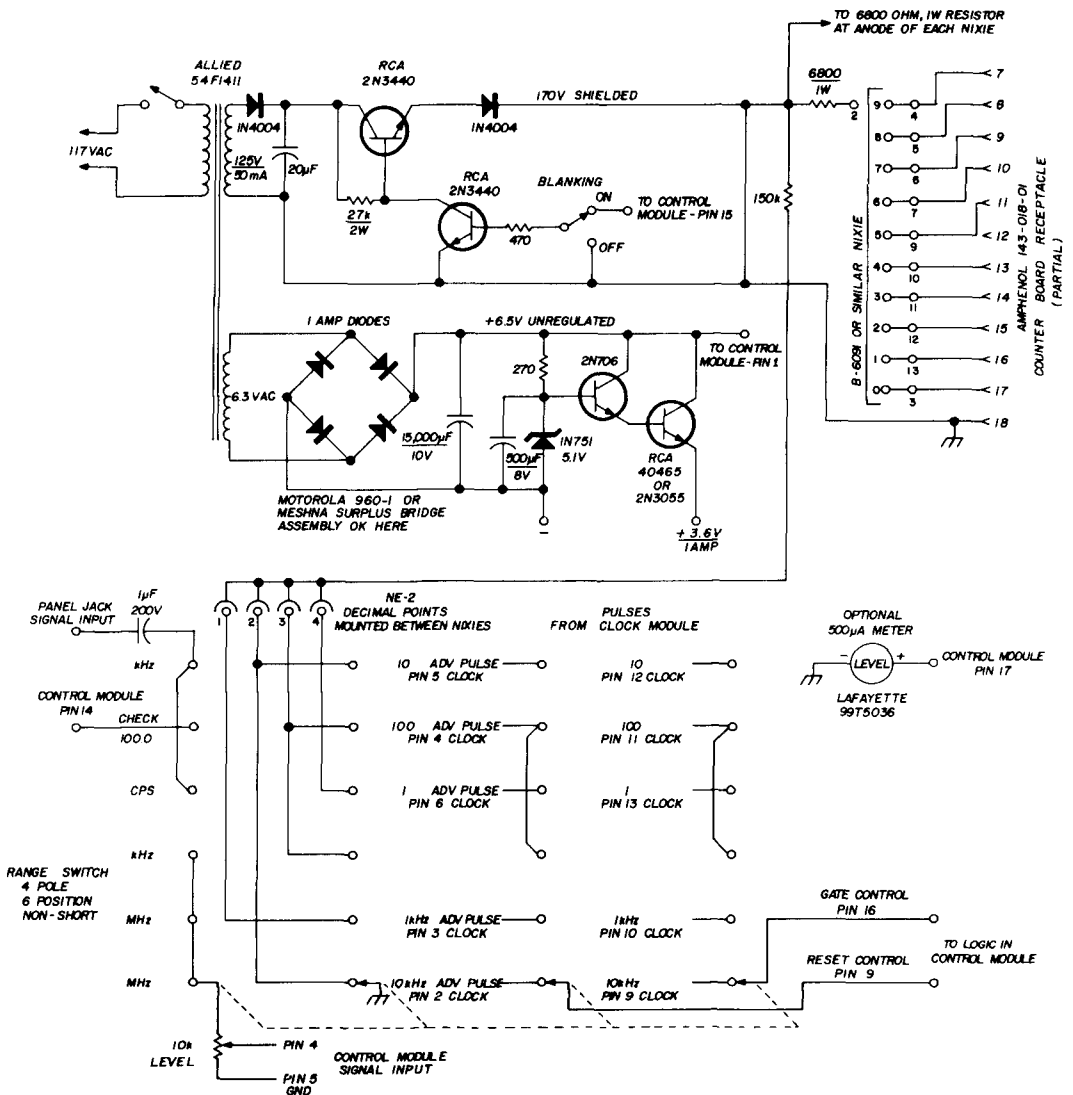


fig. 7. Power supply and range-switch schematic.

carry pulse appearing at the left-hand counter decade and locks up until the next reset pulse.

### power supply

The circuit shown in fig. 7 is a dual-purpose power supply that furnishes all operating voltages for the counter. An amplifier-switch, consisting of an emitter follower and amplifier, provides high voltage for the readout tubes. Unregulated 6.5 volts for the IC amplifier in the control module is taken from the top of

the low-voltage supply. A Darlington pair-zener configuration provides regulated 3.6 volts for the flip-flops.

### construction notes

A low-wattage soldering iron is essential when working with solid-state components. The inevitable debugging in a project such as this will be simplified if you have a vacuum-operated de-solder device, such as one of those made by Soldapult or Ungar.

The power-supply board is mounted

on 1/2-inch spacers on the rear inside wall of the minibox. The large filter capacitor, power transformer, and 2N3055 power transistor should be mounted so that the minibox cover will fit.

Negative leads should not be grounded at the power supply, but should be routed to a common point near the front of the instrument. The 170-volt supply ground return is via the outside conductor of a length of miniature coax cable; the inner conductor carries the high voltage. All power leads are in one cable, which runs along the left side of the instrument.

A standard Minibox results in a compact instrument that fits nicely on a crowded workbench. A 1/2-inch aluminum strap was bent to form a handle, which also serves as a prop to position the instrument for easy viewing.

Readout tubes were mounted on an aluminum bracket directly behind the PC board sockets. After the Nixie-tube sockets were mounted, masking tape was used to cover the sockets and the inside of the bracket. The corresponding part of the

## accuracy checks

Since the input frequency is rarely in phase with the counter gate, the displayed count varies according to the number of pulses in the gate at the time it operates. It is therefore normal for the counter to have a 1-digit error, which extends throughout its frequency range of 20 Hz to 15 MHz. At the higher frequencies, accuracy depends on the crystal clock more than any other factor; but at low frequencies, the error remains within 1 digit. One of the positions of the range switch is used to check the internal circuits of the counter. It may be, when the counter is completed, that the 100.0 test position displays 100.1. If this happens, change the 100-kHz jumper in the clock module from pin 13 of IC6 to pin 14.

The uses of this counter are not limited to its basic frequency. I have set 150-MHz communications monitors on frequency, using the 10th harmonic of a 15-MHz oscillator. W4BNE regularly checks the frequency of a MARS net on 50 MHz using a similar method.

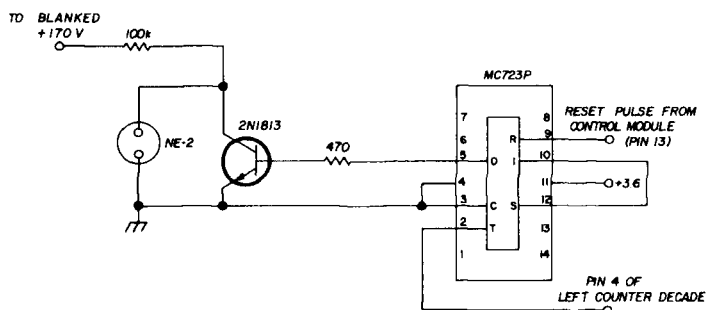


fig. 8. Overrange indicator schematic. Neon bulb illuminates when fourth counter decade put out a carry pulse.

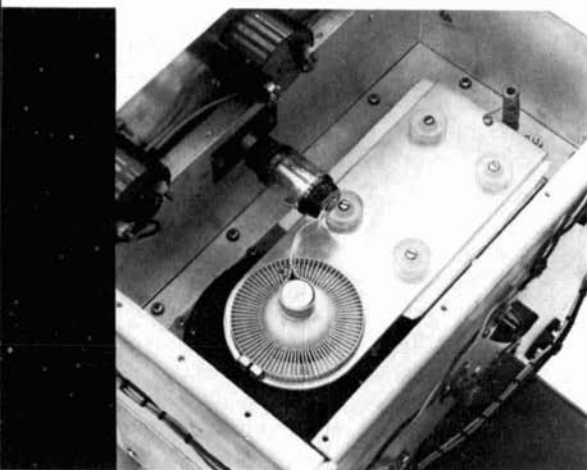
enclosure was sprayed with dull black lacquer to suppress reflections.

A panel bezel was sawed out of scrap 1/4-inch plexiglass, filed to shape, painted, and mounted over a cutout on the end of the minibox. A small glass window for the readout tubes was secured by clips. Datak dry decal transfers were used to mark the panel. The printed circuit boards were mounted on short lengths of 1/2-inch aluminum angle.

## references

1. Bert Kelley, K4EEU, "Digital Frequency Counter," *ham radio*, December, 1968, p. 8.
2. Irvin M. Hoff, W6FFC, "Mainline FS-1 Frequency Standard," *QST*, November, 1968, p. 34.
3. "Application Note AN-251," Motorola Semiconductor Products, Inc., Technical Information Center, P.O. Box 20912, Phoenix, Arizona 85036.
4. Steinback, "IC Counters and Dividers," *Electronics World*, January, 1968.

ham radio



## low-drive kilowatt linear for two meters

The Eimac  
5CX1500A pentode  
in a  
grounded-cathode  
amplifier  
using strip line  
construction

Recent articles in *ham radio* of vhf power amplifiers using strip line tank circuits<sup>1,2</sup> inspired me to boost the output of my Communicator IV to a kilowatt on 2 meters. I used an Eimac 5CX1500A pentode in a grounded-cathode linear amplifier circuit (fig. 1). No drive power is required, which eliminates the need for a buffer amplifier.

### strip line plate circuit

Details of the "sandwich" tank circuit are given in fig. 2. The grounded lower plate is slightly wider than the upper plate to accommodate the antenna loading clip. Four 10-32 screws and nuts and eight polystyrene washers hold the assembly together. Two sheets of Teflon, 15 mils thick, are used for insulation between plates. The capacitance of this sandwich measures 285 pF.

Upper and lower plates are made of 1/8-inch-thick silver-plated copper. The upper plate is cut to accommodate the tube's 3-3/8 inch-diameter cooling fins. The narrow section is cut through, and both ends are bent up and drilled for a 6-32 screw and nut. This clamps the end of the tank circuit to the tube. The lower plate is bent to form the rear support for the assembly. It is grounded by screws at the end farthest from the tube.

High voltage is fed to the plate through an rf choke at the low-impedance point of the upper plate. I used a 3-30 pF vacuum variable for plate tuning, but a capacitor with range of about 2-10 pF should be adequate to tune 144-148 MHz.

### power supplies

Plate and screen supplies are conventional (fig. 3). The bias supply uses a small line isolation transformer and a silicon-diode bridge rectifier. I couldn't find a 5-volt, 40-ampere filament transformer in any catalog or ham equipment supply store, so I used a type F530 Stancor transformer (5 V, 30 A) with an autotransformer in the primary to obtain 5 volts at the tube-socket terminals. After two hours of operation, the transformer

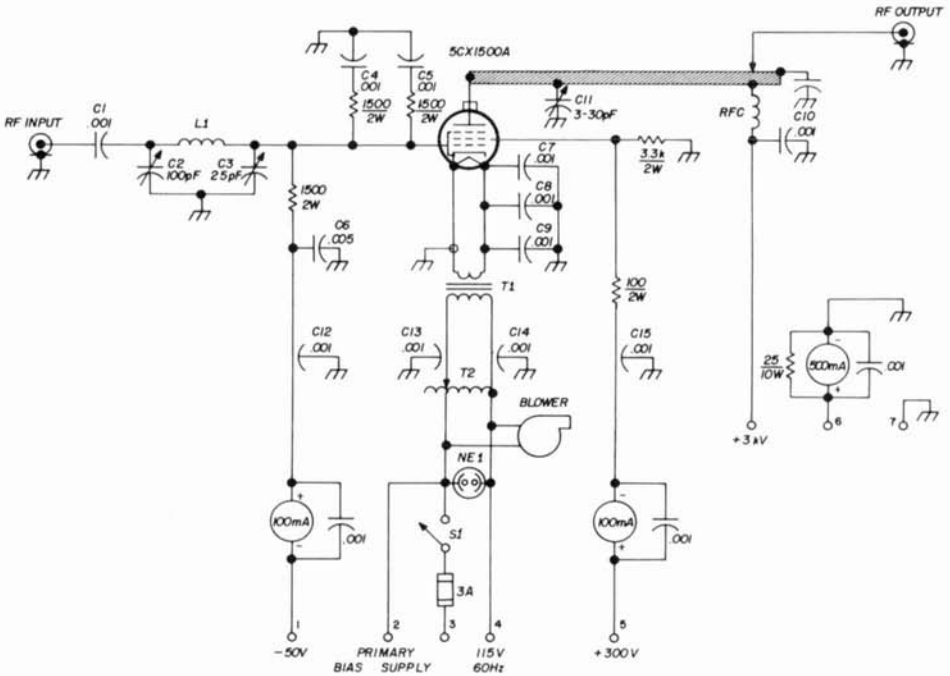
Irwin R. Wolfe, W6HHN, 3467 Rambow Drive, Palo Alto, California 94306

temperature rise was insignificant.

## enclosure

The amplifier is built on a standard 19-inch panel, which is 19¼ inches high to accommodate blower height. An alu-

minum box (fig. 4) houses the amplifier. A shelf separates input and output circuits. A 3½-inch cutout in the top plate, directly over the tube, permits cooling air to vent out of the cabinet. A perforated metal plate covers the blower cutout. An



C1, C7, C8, .001  $\mu$ F (Centralab type 8585)  
C9, C10

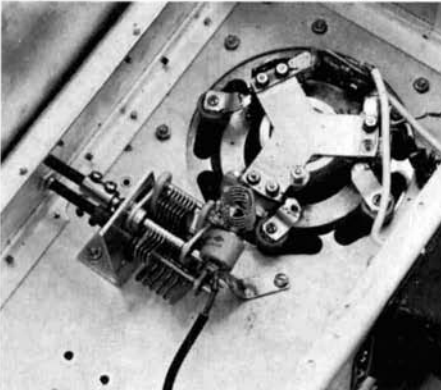
C12 - C15 .001  $\mu$ F feedthrough capacitors  
(Erie type Ck70AW-102M)

L1 5 turns no. 16 tinned copper, 5/8" diameter, 1-1/8" long

Blower must deliver 60 to 100 cfm

fig. 1. Schematic of the easy-to-drive 2-meter linear amplifier. Low interelectrode capacitance of the 5CX1500A eliminates neutralization. Third-order intermodulation distortion is  $-36$  dB.

Amplifier bottom view showing input pi network.



Eimac SK806 chimney confines air flow through the tube cooling fins. The filament transformer primary connections, grid-bias connections, and screen connections are brought out of the box with feed-through capacitors.

The upper control in the front-panel photograph is for plate tuning; the two lower controls are for the input circuit pi network capacitors.

## tuning linearity adjustment

Control of rf drive is necessary to adjust the amplifier for linear operation. I

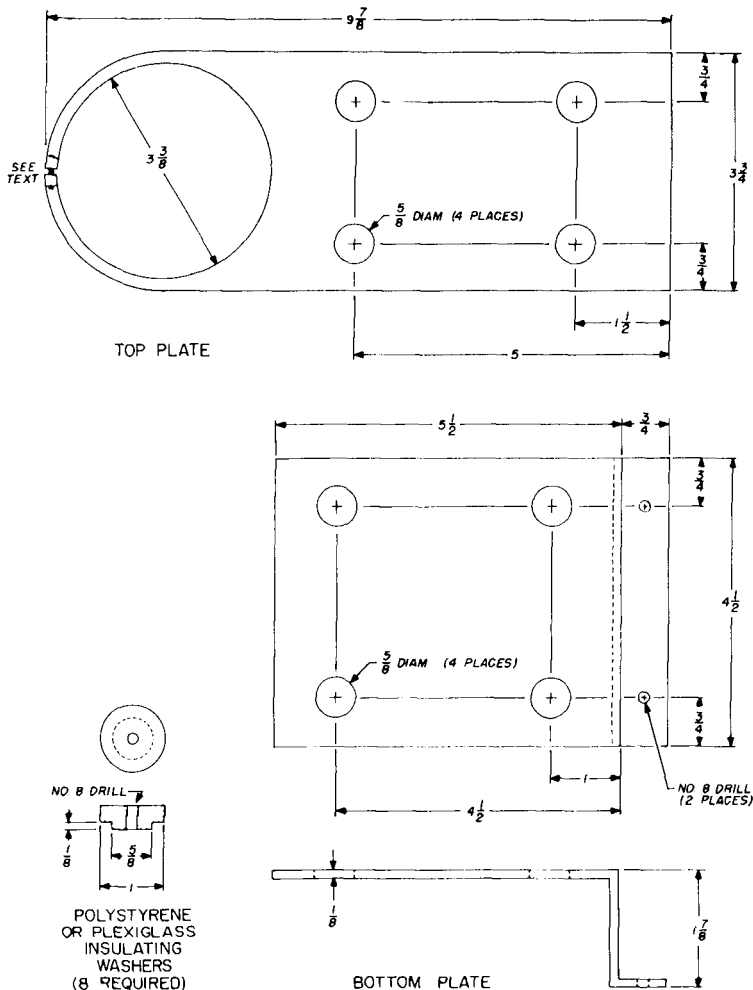


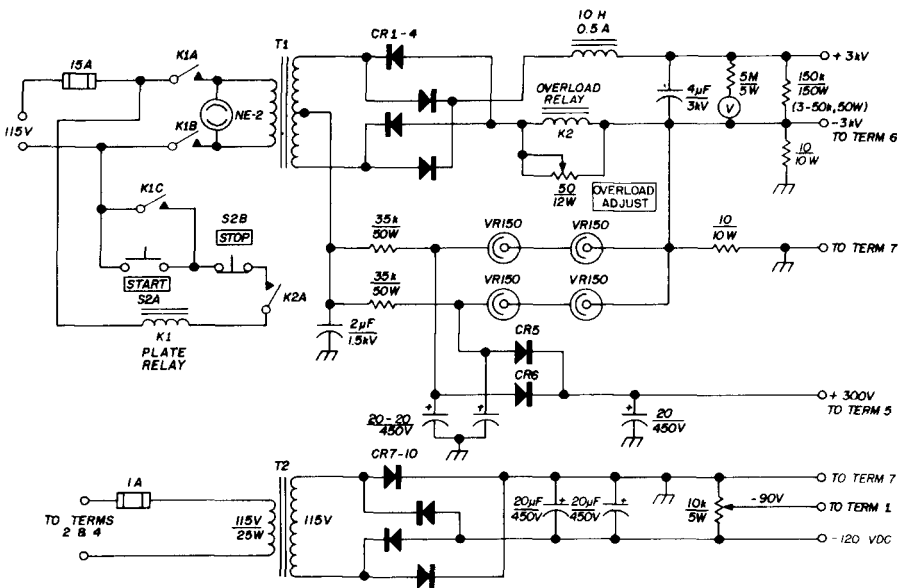
fig. 2. Construction details of the strip line tank. Material is 1/8-inch silver-plated copper separated by two 15-mil-thick Teflon sheets.

installed a potentiometer in the driver to adjust the output tubes's screen voltage. To adjust amplifier linearity, proceed as follows.

Connect the exciter output to the amplifier input through a directional coupler. Apply bias and filament power to the amplifier. Adjust both driver tuning and the amplifier pi network capacitors for maximum incident output through the coupler. Switch the coupler to reflected power and adjust the pi network and exciter tuning for a minimum, which should be almost zero. Increase grid bias to maximum, and reduce

rf drive. Connect a dummy load and an rf indicator to the amplifier. Place the antenna clip along the bottom plate at a point about 3 inches from the ground end.

Apply plate and screen power, and increase excitation until the output indicator shows power. Tune the plate capacitor for maximum rf output. Do not allow amplifier screen current to increase above 50 mA during this adjustment. Adjust drive and bias for a plate current of 350 mA. When the plate tuning capacitor is adjusted, screen current can also be used to indicate resonance.



CR1-CR4 Each diode consists of 8 series-connected 600 V, 1 amp silicon diodes

CR5-CR10 600 V, 1 amp silicon diodes

fig. 3. Plate, screen and bias supplies.

T1 3000 volt center-tapped transformer

T2 117-117 Vac isolation transformer

Linearity adjustment should be made with an oscilloscope. I used a parallel resonant circuit to couple the amplifier output to the scope. Complete details for

obtaining linear operation are given in reference 3.

Loading adjustments are made by moving the clip lead to different positions along the bottom plate of the strip line tank. Make certain that both plate and screen power are removed before making these adjustments. Replace the top plate after each new position, and resonate the plate circuit.

The 5CX1500A, with 1500-watt plate dissipation, runs considerably under its maximum ratings for amateur operation. During cw tests, it easily delivered a kilowatt into a dummy load.

#### references

1. William I. Orr, W6SAI, "2-kW PEP Amplifier for 432 MHz," *ham radio*, September, 1968, p. 6.
2. Robert I. Sutherland, W6UOV, "Design Data for a Two-kilowatt Vhf Linear," *ham radio*, March, 1969, p. 6.
3. *The Radio Amateur's Handbook*, ARRL Staff, 1969 Edition.

ham radio

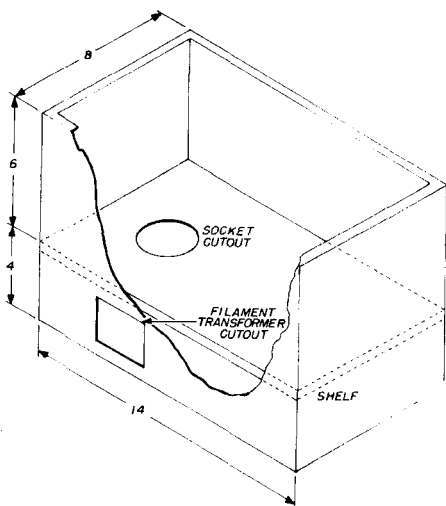


fig. 4. Rf enclosure detail. Material is 1/16-inch aluminum.

# computer processing slow-scan television pictures

A discussion  
of computer techniques  
used to enhance  
the quality of  
slow-scan  
television pictures

Of all computer applications, the processing of pictorial information is perhaps the most spectacular. Using a high-speed digital computer and its peripheral output equipment (the line printer, contour plotter, cathode-ray tube display, etc.), it is possible, for example, to transform a multitone photograph into a line drawing, and to obtain various perspective views of the object photographed. You might even simulate the pilot's view of an aircraft-carrier's flight deck together with a "movie" showing a landing on the aircraft.<sup>1</sup> Whatever the job, use of the computer to process and display pictorial and graphical information has provided the scientist, engineer, educator, artist—and yes, the radio amateur—with a highly versatile and accurate tool.

Many readers of *ham radio* may already have an appreciation for the data handling capability of the digital computer; however, the details of picture processing probably remain a mystery. For this reason, we will discuss some basic picture processing techniques. Further, we will apply the processing techniques to slow-scan television pictures to demonstrate the effects on a picture

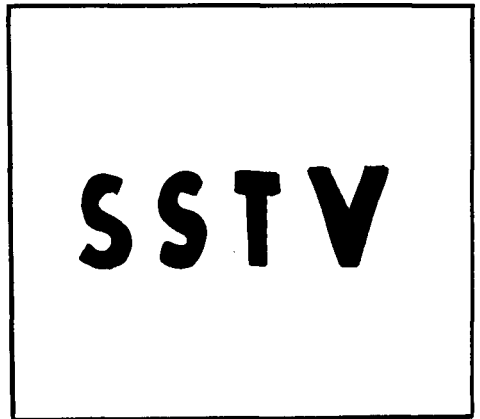


fig. 1. Sstv test card used by authors to check digitization and computer processing techniques.

Theodore J. Cohen, W4UMF, Howard L. Husted, Paul R. Lintz



produced by dynamic range compression and contrast enhancement.

### sstv fundamentals

Before examining the various aspects of picture processing, let's briefly review some slow-scan fundamentals. The pictures we processed were produced in accordance with the sstv standard proposed by Macdonald.<sup>2</sup> This standard specifies a slow-scan picture having a line frequency of 15 Hz and a frame period of 8 seconds. Pictures contain 120 lines and consist roughly of 14,400 picture elements. Horizontal sync is transmitted as a 5 millisecond burst of 1500 Hz, while the vertical sync consists of a 30 millisecond burst of 1500 Hz. Video information is transmitted at frequencies between 1500 (black) and 2300 (white) Hz.

### the pictures

The pictures processed came from two sources. The first (fig. 1) was recorded directly from the output of a transistorized slow-scan camera. By using this closed-circuit procedure and a simple four-letter black-on-white card we were assured of having an acceptable picture to test digitization and processing procedures. This test picture was initially recorded on mylar audio tape using a recording speed of 3 3/4 ips.

The second picture we processed is shown in fig. 2. Originally transmitted on 20-meter ssb by KC4USV, the picture

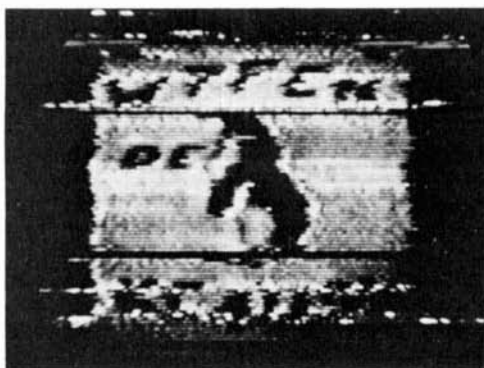


fig. 2. Single slow-scan frame transmitted on 14 MHz by KC4USV, Antarctica, and received by W7FEN.

was recorded by W7FEN. The picture's characteristics are less than ideal. Already downgraded by the fact that the multivibrator in the camera at McMurdo was not swinging through the entire 1500 to 2300-Hz video spectrum, the picture was further degraded by atmospheric noise. To the extent that the picture is far from ideal, it presents an excellent opportunity to investigate the capability of our processors.

### analog to digital conversion

The pictures were re-recorded on 1-inch, 1.5-mil telemetry tape at a speed of 7 1/2 ips. To satisfy input requirements of the analog-to-digital (A-D) converter, it was necessary to use a playback speed of 0.5 x real time (3 3/4 ips). Small plug-in RC networks were used to determine the center frequency of the discriminator. At

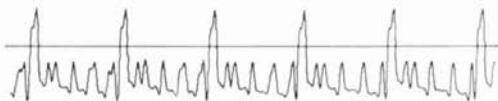


fig. 3. Successive horizontal lines of the sstv test card.

3 3/4 ips playback speed the center frequency is 750 Hz; our discriminator's center frequency, however, could not be lowered below 840 Hz.

The pictures were digitized at an equivalent rate of 2,000 samples per second; this provided a total of 16,000 data points for one complete sstv picture. After A-D conversion, the digitized pictures were placed on magnetic tape.

Oscillograph records of the sstv pictures proved helpful during processing. A sample record showing several lines of the "SSTV" test card is shown in fig. 3. Note that the sync pulses are negative, and that the downward excursions of the positive values display portions of the "S," the next "S," the stem of the "T," and the two sides of the "V." You also can see that each line is brighter on the left side than on the right. This results from the original test card having been illuminated from the left.

## picture preparation

The ideal digitized picture contains two classes of information; sync and video. The viewer is only interested in the video, while the sync insures that each line is displayed properly. The process of preparing this picture for computer processing is one of stripping off the sync and of storing the picture information in some systematic manner. However, problems related to picture digitization and quality must be overcome if we are to effectively process the pictures.

We will restrict the discussion below to the general types of problems involved in preparing a picture for computer processing.

**Identification.** As we digitized many pictures, a label was written ahead of each picture. This label consists of a number and alphanumeric title; the total number of points in the picture, normally 16,000, is also recorded. To find a specific picture the computer searches for a given number and reads the stated number of digital points into memory. The alphanumeric title is also read and is used later to describe the processed picture.

**Picture bias.** Because of our discriminator's center frequency being unavoidably high, the digitized pictures contained a negative offset, confusing the sync and video signals. Thus, a fine adjustment to the dc level was required. This was accomplished by examining the photographic readout of the digitized picture, determining the negative offset, and adding the absolute value of the offset to each picture point.

**Clipping.** We frequently observed large positive spikes in the signal. The spikes use up the dynamic range of the picture, relegating the video information to the obscure background. To meet this problem, the white level of the bias-corrected picture was determined, and all information (spikes) above this level clipped off.

**Sync stripping.** Sync pulses should be distinguished by their negative values and their length in time. At 2,000 samples per

second, a 5 msec horizontal sync pulse should contain 10 digital points, while the vertical pulse, being 30 msec long, contains 60 points. Unfortunately, the sync is not stripped easily. Since the sampling rate of 2,000 samples per second is only a nominal value, sync pulses generally contain more or less points than the theoretical 10 and 60; further, we occasionally found positive spikes within the negative sync pulses. Thus, we re-

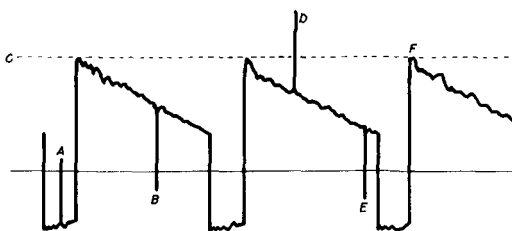


fig. 4. Hypothetical display of a "worst-case" sstv signal. Fortunately, most of the picture information we processed was free from interference!

quired that once a negative point was found, the computer interpret this as the first point of a sync pulse. The computer was then to look for the first positive point to appear next (the first picture point of the line), *but* to ignore all positive points which appeared within 8 points of the first negative point.

Similar to this problem was the presence of negative spikes within the video portion of the picture. To insure that these spikes did not trick the computer into thinking it had found a sync pulse, we required that once a line of video was found, the computer was to process at least the next 115 points as video.

Fig. 4 shows the type of digitized information encountered and the manner in which this information was processed.

Note that if the timing of the original sstv signal were perfect, and if the digitization rate were exactly 2,000 cps, the raw picture would consist of 120 lines, each line containing 123 video points. The lines we will process, however, are

made to consist of 120 video points. This is done purposely so that we can display the picture on the computer's line printer in the same manner that one types out a picture using X's, 5's, etc. (quite a popular pastime with the RTTY crowd).

### picture processing

Once the sync has been stripped from the signal and each line filled to 120 points we are ready to begin processing the picture matrix. A matrix is nothing more than an orderly array of numbers; here we allow for a matrix with up to 140 rows (sstv lines) and 120 columns (120 horizontal picture points). Let us perform the following operations on this picture

2.50 1.25 2.50 5.00 5.00 2.50 2.50 5.00 5.00 2.50 1.25 2.50

matrix:

1. Quantize the picture elements and plot the picture on the line printer

0.50 0.25 0.50 1.00 1.00 0.50 0.50 1.00 1.00 0.50 0.25 0.50

using various symbols (X's, 5's, etc.).

2. Contour the picture (line extraction).

1.00 0.75 1.00 1.50 1.50 1.00 1.00 1.50 1.50 1.00 0.75 1.00;

1 0 1 1 1 1 1 1 1 1 0 1

3. Compress the dynamic range and enhance the contrast.

Certainly, computer processing has progressed to the point where the first

X X X X X X X X X X

two operations are easily executed. The third type of processing is a bit more sophisticated, however, and generally requires a computer with a large memory. The computer we used has a rather limited core (32,000 locations), of which up to 16,800 locations can contain picture points. For this reason only a very basic type of dynamic range compression and contrast enhancement will be demonstrated.

### quantizing to n levels

Having formed a picture matrix, one

of the simplest forms of picture processing we can perform is to quantize the picture elements and plot the levels using the line printer's symbols. To do this we first determine the maximum value within the matrix and divide every number by this maximum value. Assuming we want N levels in the plot, each point is multiplied by (N-1) and 0.5 added to the product. These numbers are then truncated (numbers after the decimal point thrown away) and a specific symbol assigned to each integer.

As an example of this procedure, consider the following foreshortened sstv line:

The highest number is 5.00; when we divide each number by this value, the line values become:

Let's assume we want to plot the picture on two gray-scale levels, black and white. N is 2, and (N-1) is just 1; thus, multiplying each point by 1 and adding 0.5, we obtain:

which, when truncated, yields:

If we assign the symbol X when the picture element is 1, and a blank when the element has value 0, the line appears as:

Fig. 5 shows the test "SSTV" call card displayed in two gray-scale levels. As you would expect, the printed material requires only the black-white display for effective presentation (the dot between the S's is a blemish on the vidicon target). A printer plot of the Antarctic picture for two gray-scale levels is shown in fig. 6. Despite the fact that the original material was black and white, the two-level display is far from satisfactory because of tonal gradation introduced by transmission. This picture will require further processing.

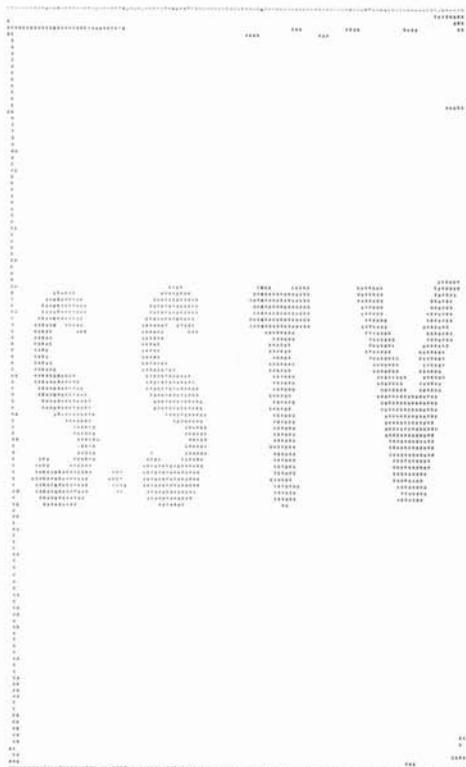


fig. 5. Line printer display of the sstv card. Displays of this type are quite popular among RTTY enthusiasts.

Printer plots of the type discussed above may at first appear to be a novelty; however, they afford the analyst with a good first-order presentation of the picture matrix and allow him to make decisions as to further processing the picture.

Note that the printer-plot pictures are spread in the vertical direction. This is a consequence of the intersymbol spacing being less than the line spacing. However, the advantage of using this form of display for a quick first look far outweighs the geometrical distortion.

One important aspect of the quantizing procedure is that we could now take advantage of the intrinsic redundancy present in the picture. We see from the line of truncated values that data points exist which may be derived from neighboring data points using some simple interpolation procedure. In the line pro-

cessed previously the fourth through tenth points can each be derived from the third point. All we have to do is transmit data where the values of the picture change, the location of this data, and instruct the processor how to reassemble the picture. Thus, for the line:

1 0 1 1 1 1 1 1 1 0 1

we transmit only:

location	value
1	1
2	0
3	1
11	0
12	1

and insist that where a value is not specified, the previous value be substituted. Here 10 pieces of data must be transmitted instead of the original 12,

fig. 6. Line printer display of the KC4USV-W7FEN slow-scan picture.



and the redundancy factor is 12/10 or 1.2. While this is not high, we can easily see that if the redundancy factor can be made sufficiently large, elimination of the redundant data points can result in a significant saving in bandwidth.

We can also consider the redundancy between successive pictures as did Inger-son.<sup>3</sup> Here, the entire picture is stored in a computer's memory and only those points which change from picture to picture by more than a minimum specified amount are changed.

### picture contours

Considerable information is contained in a multitone picture. Yet in many cases we want to retain only the essential features of the picture. For example, it may be our purpose to identify a given pattern within a background of noise; to do this we only need the outline of the pattern. What we want to do is to extract a black-and-white line drawing of the picture—that is, we seek to contour the picture at various amplitude levels (i.e.

fig. 8. Computer contour plot of the KC4USV—W7FEN slow-scan frame.

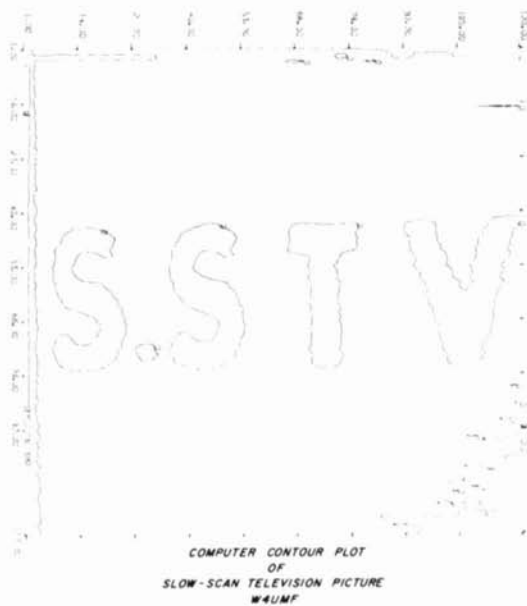


fig. 7. Computer contour plot of the sstv test card. Note that line extraction causes only the essential features of the picture to be retained.

gray levels). Standard routines are available to contour data, and we will not detail their logic here.

Contour plots of the "SSTV" card and the KC4USV transmission are shown in fig. 7 and 8. Both pictures were contoured at the 0.5 level (peak level = 1.0). In each case the essential features of the information contained in the original picture have been extracted and outlined.

### dynamic range compression and contrast enhancement

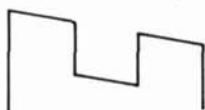
We can consider our picture elements  $B_{xy}$  to be formed by the product of an illumination term  $I_{xy}$  and a reflectance term  $R_{xy}$ .<sup>4</sup> The illumination function varies slowly over the picture so it consists of low-frequency components. The reflectance term, however, contains the picture information and is represented by high-frequency components. The brightness at a given point  $(x,y)$  in the picture matrix is then the product of the illumination term at  $(x,y)$  and the reflectance term at  $(x,y)$ . That is:

$$B_{xy} = I_{xy} \cdot R_{xy}$$



fig. 9. Five-level line printer display of the KC4USV picture. Because of poor contrast the picture can only be defined by using the third gray-scale level (0.625 on a scale of 1.0).

We can easily demonstrate the multiplicative nature of the picture as follows. Consider a picture that consists of a black square on a white background. The picture is illuminated from the left so the right side of the picture is darker than the left. One line from the center of the picture will appear as follows:



But this is just the product of the following two waveforms:



We want to reduce the effect of the

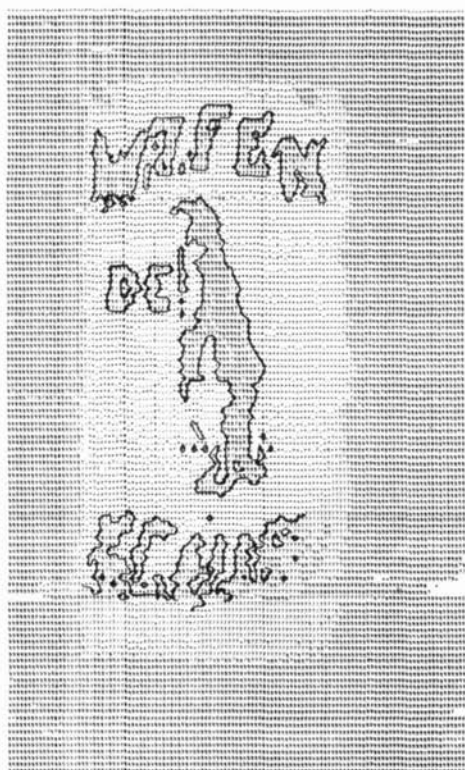


fig. 10. Five-level printer display of the processed KC4USV picture. Because of enhanced contrast an improved picture can now be outlined using only the second gray-scale level (0.375 on a scale of 1.0).

illumination term by making it more uniform. This can be done by raising the illumination term to a power  $\epsilon$  which is less than 1. On the other hand, to enhance the contrast we want to raise the reflectance term to a power  $a$  greater than 1. Thus, the processed picture is represented as follows:

$$B_{xy} = I_{xy}^{\epsilon} \cdot R_{xy}^a$$

We conveniently assume that the illumination term can be represented by a plane.

Let's apply the above picture processing technique to the W7FEN Antarctic picture. Fig. 9 is a line printer output of the unprocessed picture; five gray scales are displayed with the lower three enclosed by contours (the contours represent the .125, .375 and .625 levels of a picture for which 1.0 is the maximum



fig. 11. Contour plot of the unprocessed KC4USV picture. Again, it is only after the third gray-scale level is plotted that the picture is defined.

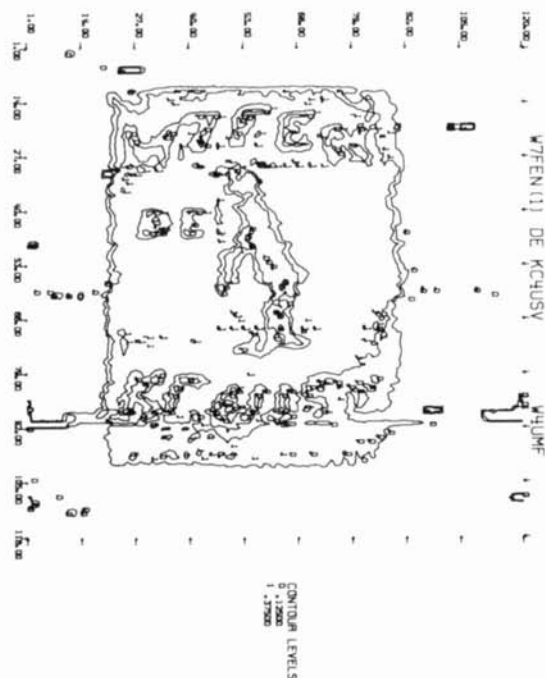


fig. 12. Contour plot of the processed KC4USV picture. As in fig. 10, only the two lower gray-scale levels must be plotted.

picture value). The picture information for the call letters and penguin is very poorly defined. After dynamic range compression and contrast enhancement, however, a more satisfactory picture is obtained (fig. 10). Here only the lower two contour levels (.125 and .375) are needed to define the picture, with the pictorial information now more in relief against a uniform background. A value of 0.5 was used for  $\epsilon$ , while the value for  $\alpha$  was set to 2.

The differences between the two pictures is portrayed in more detail by the contour plots of fig. 11 and 12. Again, the lower three and two contour levels, respectively, are contoured and plotted. Among other things, note how the penguin is better defined in the processed picture.

### summary

This, then, is a presentation of basic picture processing, one of the most interesting applications of modern computer technology. Using techniques which only a decade ago would have been costly and time consuming to implement the experimenter is now able to see both qualitatively and quantitatively the products of his labor—and he can do so with much saving in time, money and effort. The flexibility of this tool is still being explored with the presentation of moving, colored images but one of many recent advances. Whatever the application, we can be assured that picture and graphical processing by computer will shortly pervade many aspects of our lives.

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ham radio

# new look in teleprinters

Significant advances have been made in teleprinter development within the last few years. Although they won't reach the amateur market for some time, these new machines have some interesting design trends that will appeal to the amateur rtty fraternity.

This article reviews some of the new teleprinters using thermal, piezoelectric impact, and conventional impact printing techniques. All are designed for mobile use. Interestingly enough, all are also designed for use with separate keyboards. This is because of varied installation and end-use requirements—for example, police-car printers don't require keyboards. Another design trend is toward half-page printers to save space in crowded aircraft cockpits and patrol cars.

Solid-state logic and integral clocks permit a wide variety of input codes and printing speeds. The most commonly used codes are Baudot and the American Standard Code for Information Interchange (ASCII). The latter is similar to Baudot but has eight levels, making possible 128 characters.

## NCR thermal printers

National Cash Register has developed a technique for true thermal printing. Their printer has no moving parts except in the paper-advance mechanism. The secret to this technique is a special NCR-developed

thermochromic paper. The paper has heat-sensitive chemicals dispersed throughout. The chemicals change to a blue-black color when heated by the thin-film print head. The resulting copy will not smear and is insensitive to light. Print quality is as good or better than the best impact printing.

The printer accepts conventional information codes. Speed is in the medium range—up to 300 wpm. The miniature printer has 26 characters per line, while the full-page machine has 80 characters per line.

The incoming signal is processed in a

**Motorola TT-580 miniature teleprinter. The DATA position of the speed switch is for ASCII code; others are for various speeds of Baudot.**



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solid-state logic section, which drives the print head. The head consists of a matrix of thermal elements that apply heat instantaneously to discrete dots. On a print command, the desired elements are heated, forming dots on the paper to make the characters. Each character is formed from a 5 x 7 dot matrix. Line feed is automatic upon completion of a line. Since the print head has no moving parts, there's no need for a mechanical carriage return. The printer is extremely quiet, both acoustically and from a radio-frequency interference standpoint.

NCR has also developed a thermal tape printer/reader that handles either thermal or conventional, punched tapes interchangeably.

### piezoelectric printers

Motorola's TT-580 is classed as an impact printer, but its design is different from conventional impact units. As with all new printer designs, the TT-580's solid-state electronics can be adapted to handle any of the standard input data codes.

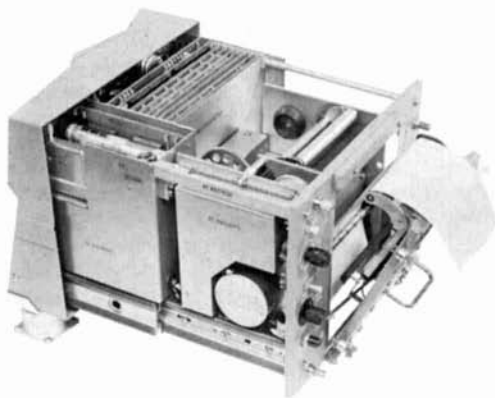
The novel feature of the TT-580 is its character-printing method. The hammer consists of a brass plate sandwiched between two 0.009-inch-thick plates of lead titanate zirconate—a piezoelectric device. A voltage applied to the hammer causes it to flex. The hammer flexes in one direc-

tion then reverses, resulting in amplitude A (fig. 1).

Dots are produced when the hammer impacts pressure-sensitive paper against a helical platen. Characters are formed on a dot-by-dot basis, using a conventional 5 x 7 matrix. The unit uses only six crystals to print all 30 characters. The paper moves in a continuous vertical flow. The printer weighs only 15 pounds; power consumption is a mere 5 watts.

Motorola also makes the VP-100 printer, which is just slightly larger than a cigar box. A special code is used that requires a wider bandwidth than Baudot. However, the code provides communication security and higher immunity to

The TT-580 with cover removed.



The Codamite TT-587 printer used by the U.S. Marine Corps.



man-made interference. A selective calling feature allows messages to be sent either to individual stations or to all stations simultaneously.

### new impact printers

Anyone familiar with World War II machines would be amazed at the clean, simple design of the Codamite printers developed by Bill Johnson, W6MUR,\*

\*Amateurs who haunt the 20-meter band will surely remember W6MUR's impeccable cw signal—an inspiration for all who aspired to good radio-telegraphy. **editor**

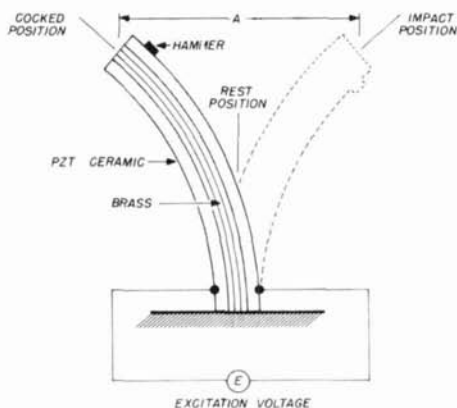
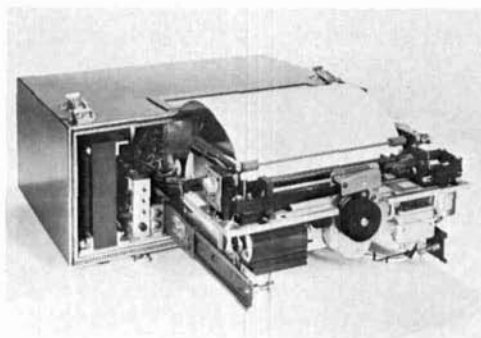


fig. 1. Piezoelectric hammer used by Motorola. The bimorph bender unit is made from two pieces of PZT ceramic bonded to a brass plate with conductive epoxy adhesive.

and his staff. These are half- and full-page units for military and law-enforcement use. Their design is a radical departure from conventional impact printers.

The Codamite series uses three pre-



Inside view of the Codamite TT-587. Unit is packaged to reduce rfi and is ruggedly designed for field use.

cision stepping motors to index the type font, which is in a conventional 8 x 8 octagonal matrix. The type is made from a special metal-plated plastic. The stepper motors are coupled by high-strength, metal-taped pulleys. One motor rotates the type font, a second traverses the printing hammer, and a third translates the font. A miniature solenoid acts as the hammer. The ribbon is a mobius loop,

ingeniously re-inked, and very easy to replace.

While the new mobile printers are half-page units, carriage return and line feed are designed so that no characters are lost when reproducing full-page copy. The TT-587, shown in the photos, is a special design for tactical military and cryptographic use. Note the features employed to reduce rfi: fingerstock shielding, double enclosure, and screened paper-feed window.

## conclusion

The case for using rtty printers in police cars and other mobile installations is a strong one. Radio frequencies are used to better advantage, message security is obtained, and hard copy provides higher accuracy and a complete record of the message. It's a good bet that printers will be used in most of the country's public-service vehicles within the next few years.



The Motorola VP-100 miniaturized teleprinter. It uses a special code for communications security and features selective calling.

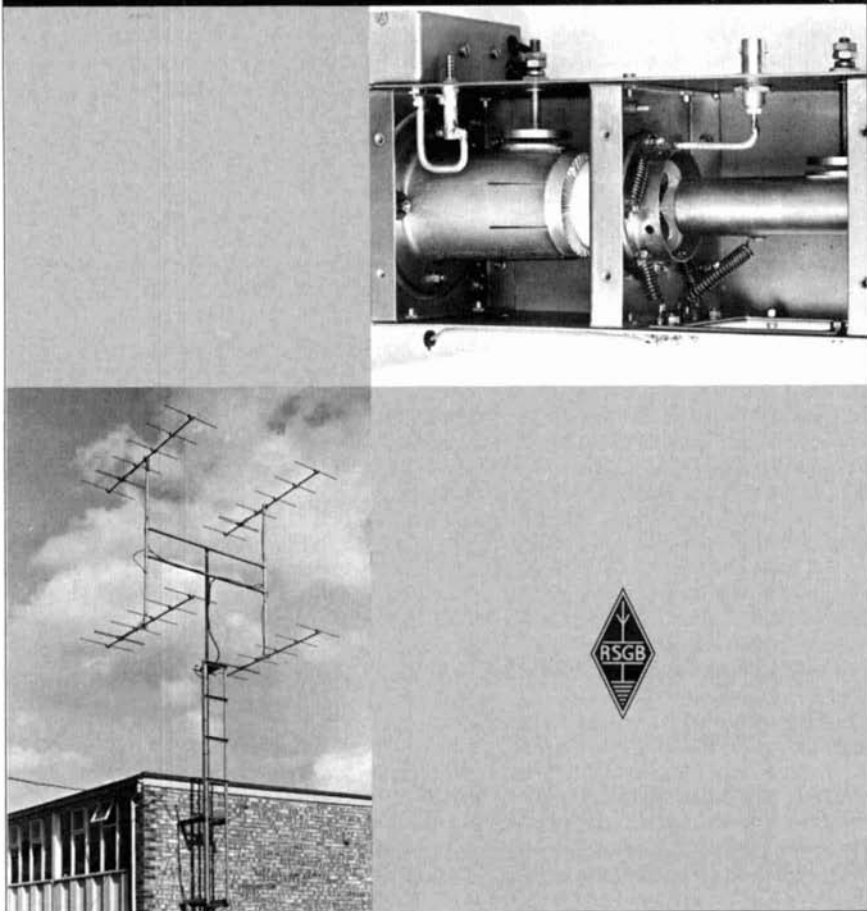
The trend in new teleprinters is toward light-weight, compact, easily maintainable designs. The price range of units described in this article is from \$800 to over \$12,000. However, the day will come when you can have a complete rty station in the same space occupied by your transceiver and at a comparable price.

ham radio

# vhf-uhf manual

BY G.R.JESSOP, C.Eng., MIERE, G6JP

published by the Radio Society of Great Britain



If you have any interest in the frequencies above 30 MHz then you need this book. It is probably the most comprehensive work of its kind ever produced, ranging from advanced material to simple circuits for the beginner to vhf. An attractive layout and clear style make the VHF/UHF Manual a most worthwhile addition to your library.

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## a solid-state rf signal generator

This instrument  
features  
automatic level control  
and  
narrowband  
fm sweep

One of the most useful items of test equipment is a good signal generator. The instrument described in this article has features found in expensive manufactured equipment, yet it can be built in a few evenings for the price of the components.

Solid-state construction results in small size and light weight. The tuning range is from 120 Hz to 95 MHz. An automatic level control and narrowband fm sweep circuit are included. Power supply and modulator are integral in the design.

### description

A block diagram is shown in **fig. 1**. The oscillator is a Hartley in a grounded-collector circuit.<sup>1</sup> The oscillator drives an emitter follower, which provides the low-impedance output. The automatic level control eliminates the need for an output level meter and compensating control, which must be adjusted with frequency change. The output is constant within 1 dB.

Frequency sweep is produced by a varicap across the oscillator tank. Sweep

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voltage is generated by a unijunction oscillator, which also provides amplitude modulation. Rf output is varied by a switched attenuator in five 20-dB steps. A manual level control is also provided. Maximum output is 100 mV rms; minimum output is about 0.1 microvolt.

### basic circuit

The oscillator, automatic level control, and attenuator are shown in **fig. 2**. The alc consists of a diode detector followed by a dc amplifier that controls the oscillator's base current. One end of the MV1626 varicap is at dc ground through a 1-meg resistor; sweep voltage is applied at this end. The other end of the varicap receives a variable voltage supplied by the "fine tuning" potentiometer.

The tuning capacitor is a broadcast-receiver variable. If you have one with

able amount of the total tank inductance, so they should be as short as possible.

The value of Q1's unbypassed emitter resistor, R1, and L1's tap are determined by trial. Normally, the tap will be between one-fifth and one-quarter of the way down from the top of the coil. The oscillator should just sustain oscillation, and output should be constant across each band (with the alc out of the circuit). These requirements are met by using the optimum combination of L1's tap and R1's resistance. Here's how it's done.

First disable the alc by removing the end of the 18k resistor that goes to Q4's collector. Connect the end of this resistor to +5 volts. Then, for each band, adjust L1's tap and R1's value so the oscillator just sustains oscillation over most of the band. Plenty of overlap will exist between bands, so don't be concerned if the circuit stops oscillating at the low ends. Output level can be checked with a vtvm connected to Q3's gate.

Coil constants are given in **table 1**. Tap the coil carefully removing insulation from part of one turn, then solder a length of fine wire to it. Take care not to short adjacent turns.

After the oscillator is working well over each band, reconnect the 18k resistor to Q4's collector and adjust the 10k trimpot for about -1 volt at the gate of Q3 (measured with a vtvm). The trimpot will likely have to be touched up a bit to get the same output level over each band.

### the attenuator

A tee rather than a pi attenuator was chosen because it's easier to obtain the required resistance values. The desired values are 40.9 ohms and 10.1 ohms. Standard 5 percent values of 43 ohms and 11 ohms will result in an attenuator impedance of about 55 ohms rather than 50 ohms, but the attenuation will be very close to 20 dB. It's important that the resistors be carbon composition, and the lower the wattage the better. The smaller resistors have a lower inductance, thus

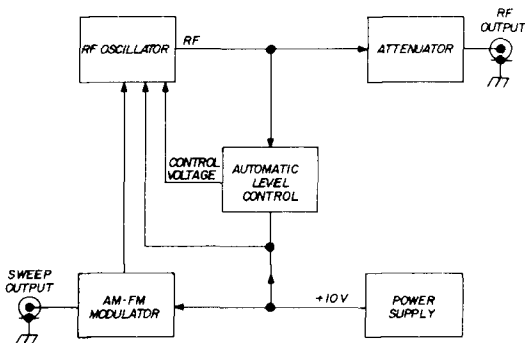


fig. 1. Block diagram of the solid-state signal generator.

built-in trimmers, either remove them or set them at minimum capacitance. The tuning dial is a dual-ratio unit made by Jackson Brothers in England. (Miller makes a similar unit in the United States.) To obtain stability and smooth tuning, the same care should be used in construction as when building a vfo.

### construction

Coil and bandswitch layout require some care. For the highest-frequency band, capacitor leads contribute an appre-



table 1. Coil data.

Band	frequency (MHz)	inductance	remarks
1	.12 - .28	2.5mH	a 4-pie RFC tapped between first two pies
2	.45 - 1.0	350 $\mu$ H	Miller 9012
3	2.2 - 5.5	30 $\mu$ H	Miller 4407
4	5.5 - 18	3 $\mu$ H	Miller 4404
5	16 - 55	0.25 $\mu$ H	5 turns on $\frac{1}{4}$ " dia, slug-tuned form
6	25 - 95	0.025 $\mu$ H	a hairpin of #14 AWG $\frac{1}{2}$ inch long and $\frac{1}{2}$ inch wide

a filtered output of 15 volts. The filter drives an emitter follower, whose base voltage is fixed by a zener. Any zener between 10 and 12 volts will be suitable.

The modulator is a simple unijunction relaxation oscillator coupled into a source follower. The source follower output is

switched either to the varicap in the fm mode, or through a filter to the base of the rf oscillator in the a-m mode.

For a-m, the modulation frequency is 1000 Hz, which can be set by the trimpot. For fm sweep, the frequency should be quite low—about 5 to 10 Hz.

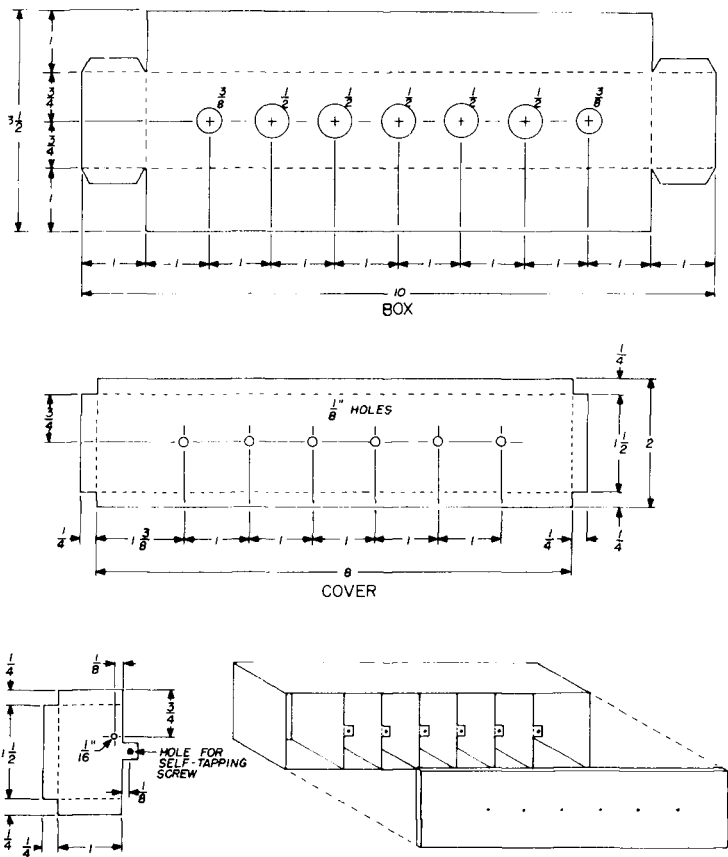


fig. 3. Layout for attenuator enclosure. Material can be thin brass sheet or "tin can" stock.

SHIELD (6 REQ'D)

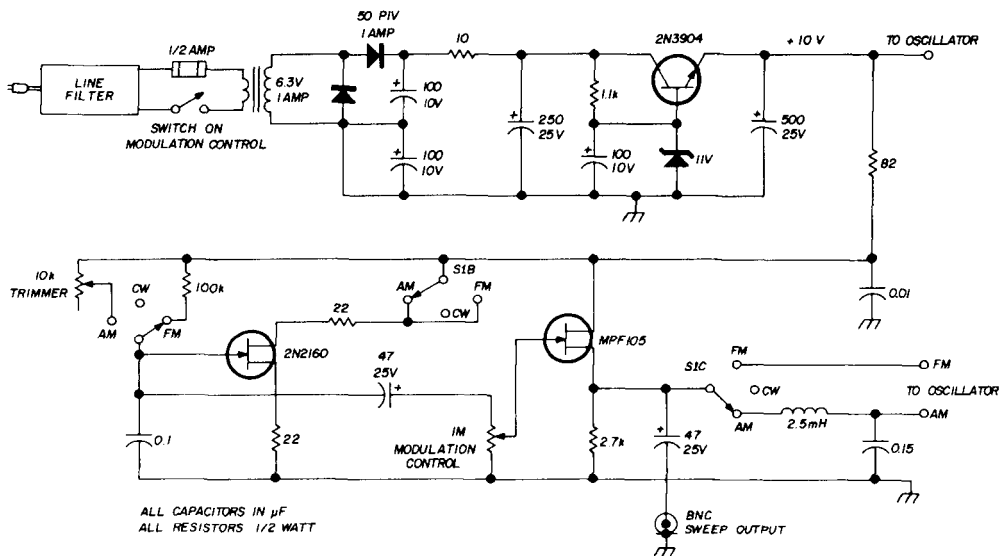
Because the supply voltage is rather low, you may have some difficulty getting the unijunction oscillator to operate with the required high value of emitter resistance. Use the highest resistor value that sustains oscillation.

The LC filter in the a-m position smooths the sawtooth waveform into a more sinusoidal shape. Ideally, the choke and capacitor should resonate at the modulation frequency. However, it's not too important that the waveform be sinusoidal.

attached to the chassis under the oscillator compartment. The construction of the filter is shown in **fig. 5**.

The 110-volt ac input enters the chassis through another low-pass filter. I was fortunate enough to find several good line filters at a local surplus emporium. However, a suitable unit could be made by using two more low-pass filters similar to the one in the positive-voltage line. They should be enclosed in a metal box.

The 110-volt ac input should enter the chassis through a male plug mounted



**fig. 4.** Power supply—modulator schematic. A simple voltage-doubler, zener regulated supply is used. The modulator supplies either a-m or fm sweep voltage.

The degree of amplitude modulation and the sweep width are controlled by the "modulation" pot. Sweep voltage is fed to a BNC connector on the chassis rear apron for connection to a scope.

### shielding and layout

The rf oscillator must be well shielded—this means **no** extra holes in the compartment. In most signal generators, rf leakage occurs primarily through the power-supply circuit into the ac line. To reduce this, the positive supply voltage enters the oscillator compartment through a two-section low-pass filter

inside the filter box. The entire filter assembly should be bolted to the chassis wall.

Make sure the ac line enters the chassis *through* the filter. It's pointless to bring the ac line into the chassis through a grommited hole and then connect it to the filter. Enough rf will be floating around to couple into any unshielded length of line cord.

General layout isn't critical. The power supply is constructed mostly on a piece of punched board. The modulation-sweep circuit is also constructed on punched board. The power supply is



mounted below chassis; the modulator-sweep circuit is mounted on top of the chassis behind the "modulation" control next to the oscillator enclosure.

Coils are mounted on a vertical plate near the end of the bandswitch. The coils

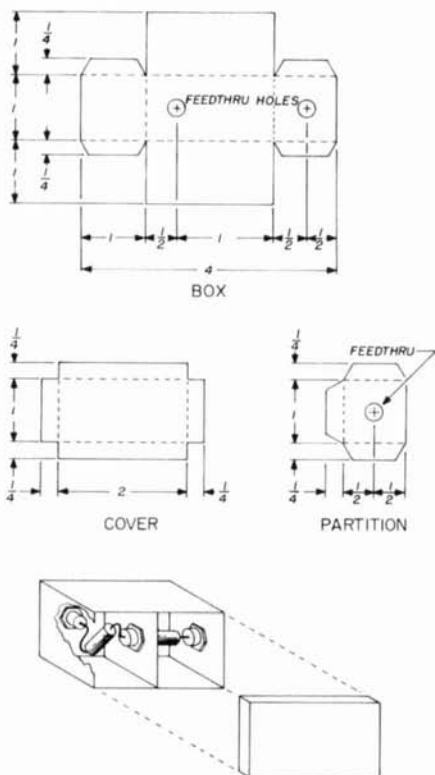


fig. 5. Enclosure details for the low-pass filter. Shielding is important, since the positive supply voltage enters the oscillator through this unit.

extend around and alongside the band-switch. The emitter follower and alc were built on a small piece of punched board.

The enclosures are made from fairly thin brass. Most of the rigidity is obtained by using a 1/8-inch-thick front panel. A bottom plate is necessary if you don't use a cabinet.

#### reference

1. L. Nelson-Jones, "Wide-range General Purpose Signal Generator," *Wireless World*, April, 1968.

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# temperature alarms

## for high-power amplifiers

Some simple circuits  
to protect  
expensive components  
from overtemperature  
damage

The most expensive component in a high-power linear amplifier is usually the tube, which can cost from \$30 to \$60 or more; yet the important precaution of protecting it from overtemperature damage is often neglected.

Although current overload can ruin a tube, the ultimate cause of its destruction is often excessive heat. A simple and dependable temperature alarm is therefore a worthwhile backup to the forced-air cooling system and protective circuits used in most high-power equipment.

This article describes several temperature alarm circuits suitable for linear amplifiers. They were tested, although not all were specifically developed, for such an application. Similar circuits can be used in other equipment where protection against overtemperature is desired.

### temperature sensors

A temperature alarm consists of a sensing device and a control circuit. For low-temperature applications, such as in the common fire alarms, many simple devices may be used. An example is an extremely thin wire that melts when exposed to prolonged overtemperature.

With high-power amplifier tubes, bulb temperature of the order of 200° C are common. A temperature alarm for this application should react to a relatively small temperature rise rather than a drastic increase. Also the sensor must be suitable for use with a specific type of thermistor.

### thermistors

Thermistors are semiconductors whose resistance to current flow is inversely proportional to temperature. They're available in many forms and with many operating characteristics. For high-power-tube protection circuits, the bead-type thermistor is most suitable. The glass bead construction permits operation to around 600° F, which is far higher than would be encountered in a protection circuit for a high-power amplifier tube.

The bead thermistor has the fastest response of all types. Depending on individual specifications, resistance changes from maximum to minimum in about two seconds in response to a sudden temperature change. The small size of the bead thermistor allows placement close to the device to be protected.

The circuits in **figs. 1** and **2** have different features. All can be powered by the ac heater supply in a linear amplifier, so a separate power source isn't required. When the circuits aren't triggered, current drain is only a few milliamperes.

### simple circuits

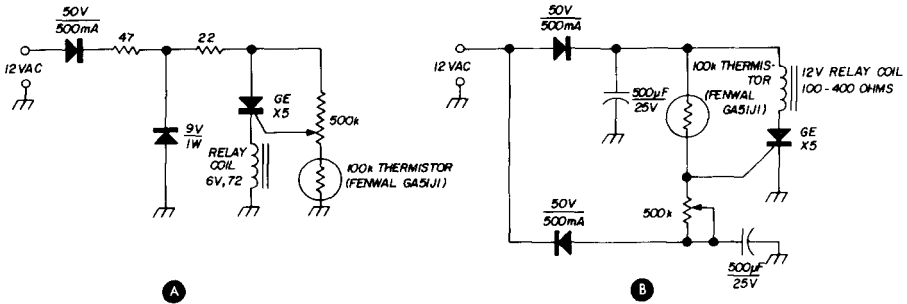
The circuit of **fig. 1A** can operate a relay to activate a warning light or buz-

John J. Schultz, W2EEY, 40 Rossie Street, Mystic, Connecticut 06355

zer. (The relay contacts aren't shown in the schematic.) The 500k pot is set so that when the resistance of the nominal 100k thermistor decreases sufficiently, the scr conducts and energizes the relay. No turnoff or reset switch is necessary for the scr, since current through the scr will fall below its holding value. When the thermistor returns to its normal operating temperature, the alarm will turn off automatically. The zener stabilizes the alarm circuit's operating point against changes in supply regulation.

### direct audible warning

In the circuit of **fig. 2A**, a dc voltage doubler provides operating power, and a zener is used as a voltage regulator. When the thermistor resistance decreases, the scr conducts, and the 1  $\mu\text{F}$  capacitor discharges through the scr and the speaker. This causes the scr to return to a nonconducting state. The capacitor then discharges through the 87k resistor. As long as the thermistor resistance remains low enough, the cycle repeats at a rate determined by the RC time constant.



**fig. 1.** Two simple temperature alarm circuits that combine SCRs and thermistors. The thermistor is a Fenwal GA51J1; the scr is a 50 volt, 1.6 amp unit from Allied Radio.\*

The circuit of **fig. 1B** is extremely simple and stable. No regulator is required, since any changes in source voltage are reflected equally across the series combination of the nominal 100k thermistor and the 500k pot. Again, when thermistor resistance decreases, the scr conducts and energizes the relay coil. With the larger 500  $\mu\text{F}$  capacitors shown, the alarm circuit will remain on once triggered. It can be turned off (when the thermistor temperature returns to normal) only by switching off the supply voltage or by using a normally closed pushbutton switch in series with the relay coil.

### large ambient variations

The circuit of **fig. 2B** is useful for large changes in ambient temperature. The simpler alarm circuits, of course, can't discriminate between a rise in bulb temperature and a large increase in ambient temperature. A bridge circuit is used, in which a reference thermistor is located away from the immediate heat area of the device being protected, and a sensing thermistor is placed next to the device.

An increase in ambient temperature affects both thermistors equally, and the bridge remains balanced. When the sensing thermistor's resistance falls to a preset value below that of the reference unit, the bridge becomes unbalanced, the scr conducts and the relay energizes. One 5k pot is used to balance the bridge for ambient conditions, and the other is used to set the point at which the alarm is to be activated.

\*Allied Radio Corporation, 100 N. Western Avenue, Chicago, Illinois 60680. The 50 V, 1.6 A SCR is catalog no. 49C3GEX5GE; Fenwal GA51J1 thermistor is no. 60F9909; Fenwal GB32J2 thermistor is no. 60F991.

## construction notes

The circuit should be breadboarded first, because construction will depend on the relay and thermistor used as well as conditions for mounting the thermistor next to the device to be protected.

A soldering iron tip moved near the thermistor makes a good temperature

ature rating is slightly lower than that of the glass envelope.

Such placement is difficult and may involve contact with high voltages, so the thermistor can be anywhere near the upper portion of the tube envelope. If the amplifier is subject to movement, as in a mobile installation, the bead thermistor

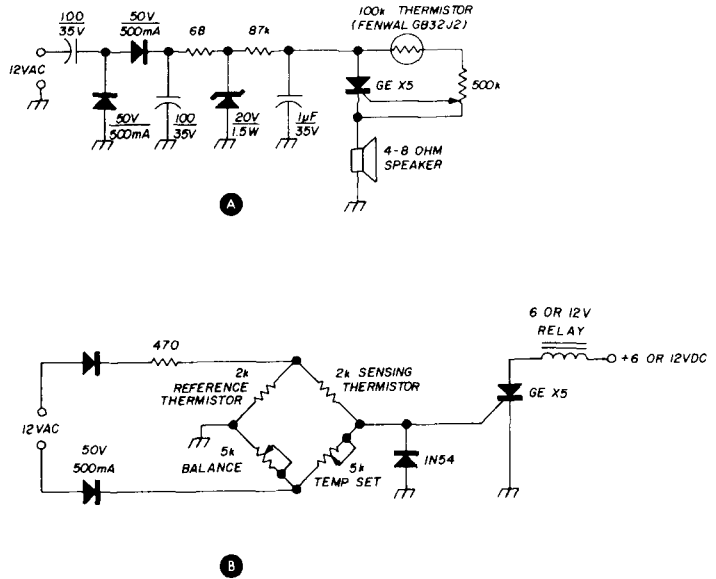


fig. 2. Two useful circuit variations feature an audio alarm (A), and a comparator circuit (B).

simulator. Don't let the iron remain in contact with the thermistor, or it will be destroyed.

The breadboard should be set up in a clear area. Handling a glass-bead thermistor is like working with a dust speck with two leads attached. If the thermistor is lost on a cluttered workbench, forget it!

The sensing thermistor can be located next to a tube, for instance, and the other components can be remotely located. Or the thermistor and alarm-circuit components can be grouped together. Since only dc is involved, there's nothing critical about wiring.

## thermistor placement

The bead thermistor must be as close as possible to the device to be protected. For a tube, it should be in contact with the seal, because the tube's real temper-

ature should be held with epoxy cement or a ceramic adhesive.

A similar mounting method can be used with transistors. Special care must be taken to keep the fine wires of the thermistor from contact with the transistor's metal case. Only the glass bead should contact the transistor. A high-temperature cement should be used to place the thermistor and its leads around the area where the bead contacts a metal case.

## operation

With the device to be protected operating normally, set the alarm circuit so it just ceases to operate. If you can safely simulate an overload condition, the alarm can be set to operate for any desired overload.

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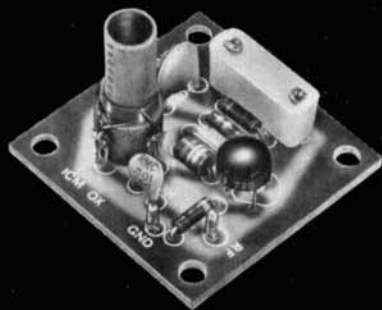
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# scr regulated power supplies

**Silicon-controlled rectifiers** as power-supply regulators have many advantages over transistors or vacuum tubes. The scr is an electronic switch that may be either *on* or *off*. Transistors or tubes also may be operated in either of these states, but generally they're used as variable resistors that change value at a rapid rate to maintain constant power-supply output. Such operation causes heat problems that limit maximum output.

Because of low voltage ratings of transistors and low current ratings of vacuum tubes, transistors have been used in low-voltage, high-current regulators and vacuum tubes in high-voltage, low-current regulators. Silicon-controlled rectifiers are now available with ratings of a thousand volts and several hundred amperes. Therefore, scr's can be used in regulated power supplies instead of transistors and vacuum tubes.

Series regulators are more efficient than shunt types, so the following discussion is confined to series-type scr regulator applications.

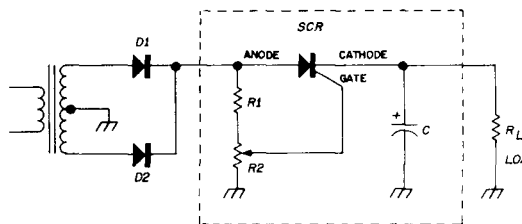
## operation

The basic scr regulator circuit is shown in **fig. 1**. It consists of two resistors, an electrolytic capacitor, and an scr. Note that the regulator is inserted between a full-wave unfiltered rectifier circuit and the load. This circuit provides a regulation against changes in load current and a variable output, which is controlled by R2.

The circuit operates as follows. When power is applied, pulsating dc appears on the scr anode and across voltage divider R1, R2. Adjusting R2 provides a voltage for the scr gate.

For convenience, let  $E_a$  represent the

maximum anode voltage and  $E_g$  the maximum gate voltage, as shown in **fig. 2**. For an scr to conduct, both gate and anode must be positive with respect to the cathode. To turn off an scr, the anode must be negative with respect to the cathode. On the first cycle conditions for conduction are met, and the scr conducts, which charges the capacitor. Near the end



**fig. 1.** Basic scr regulator (dashed box). Circuit provides regulated load current and variable output voltage, adjusted by R2.

of the first cycle, the scr turns off after the anode goes negative with respect to the cathode. The capacitor voltage keeps the cathode at a positive potential with respect to ground. If the capacitor voltage is larger than  $E_g$ , the scr will not conduct on the next cycle: in fact, several cycles may pass before the voltage on the capacitor drops below  $E_g$ . When this happens, the scr again charges the capacitor, and the process repeats.

The output is limited approximately to  $E_g$ , with a sawtooth ripple component determined by R1 and C.

Increasing C increases filter action by increasing the time constant, which prevents the capacitor from charging to a voltage much higher than  $E_g$ . Output voltage can be either increased or decreased by adjusting R2. R1 prevents

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excessive gate current when R2 is adjusted for maximum output. Changes in RL will not vary output voltage. Higher load currents increase sawtooth ripple frequency to a maximum of 120 Hz for 60-Hz power. Minimum ripple frequency can be smaller than 1 Hz with large values of C and RL, which means the scr conducts once every second or so. Remember, the sawtooth ripple component is caused by the scr conducting.

### low-voltage supplies

Suppose the transformer of fig. 1 is rated at 100 watts, and  $E_a$  is 30 volts. If R2 is adjusted for 20 volts, the load could draw 5 amperes. This, of course, assumes

sink with mica washers. The output can be regulated for changes in line voltage with a zener across R2. If you want more than one output voltage, another regulator can be connected to the junction of D1 and D2 in fig. 1. The potentiometer could be adjusted to give the second output voltage. Since output is a function of the potentiometer setting, R2 can be calibrated in volts, eliminating an output voltmeter. R1 and R2 aren't critical and can be determined from the minimum and maximum scr gate currents. As previously stated, R1 limits the maximum gate current if R2 is adjusted for this voltage. The capacitor should be as large as practical.

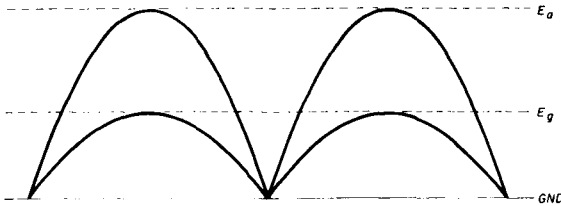


fig. 2. Output waveforms demonstrating scr operation.

the transformer is 100 percent efficient and no power is lost in the scr. If output is reduced to 10 volts, the load could safely draw 10 amperes. The load power is independent of output-voltage ampli-

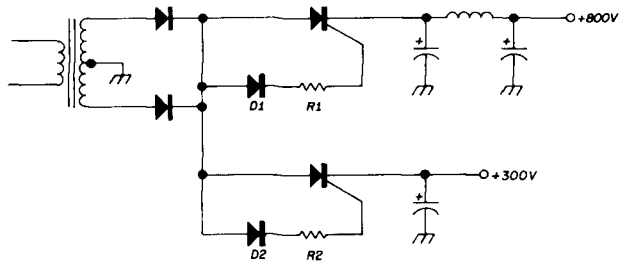
### high-voltage supplies

The techniques discussed for low-voltage supplies may be used for high-voltage power supplies—with a few precautions.

The gate-to-cathode potential could be exceeded after the capacitor is charged. For instance, assume the capacitor is charged to 200 volts. When the ripple voltage is zero, the gate will be 200 volts below the cathode. This will cause a short to develop at the gate-to-cathode junction. To prevent this, a diode is inserted in series with the gate (fig. 3). The scr peak inverse rating must be equal to, or greater than,  $E_a$  of fig. 2.

If the adjustable output feature isn't

fig. 3. An scr-regulated supply without adjustable output control. R1, R2 can be determined with a decade resistance box; D1 and D2 prevent gate-to-cathode short circuits.



tude. For high load currents, the scr must be mounted to a heat sink which, in most cases, could be the chassis. The scr must be electrically insulated from the heat

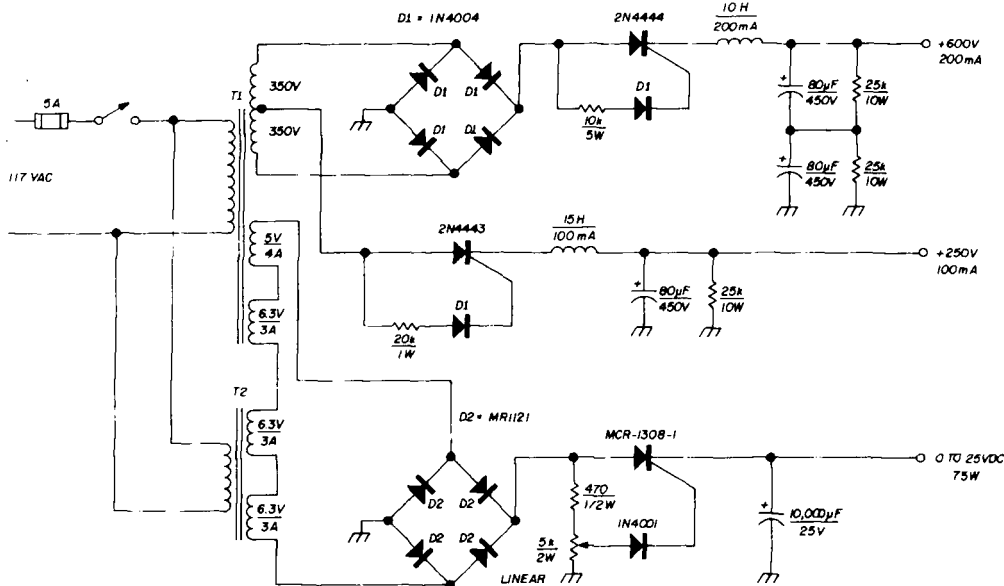
needed, and you wish some degree of regulation for load-current changes, the circuit of fig. 3 provides regulated outputs of 800 and 300 volts. With loads

removed, the regulators prevent the output voltages from increasing. R1 and R2 are best determined by using a resistance decade box: resistance is changed until the required output voltage is obtained. This allows transformers with higher voltages than required to be used, since

Don't forget to insulate the scr's from the metal chassis with mica washers. If a cabinet is used, it should be well ventilated.

### conclusions

These techniques have been used in



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fig. 4. Practical power supply using scr's. The pot in the low-voltage unit can be calibrated directly in volts, eliminating an output voltmeter.

output voltages can be reduced to any value by adjusting the gate resistors.

### practical circuit

The schematic of fig. 4 is a regulated supply that provides useful voltages for many amateur applications. The precautions about mounting the scr's to heat sinks should be observed. The transformers, of course, occupy the most space. They can be mounted on metal chassis, which can also serve as a heat sink for the scr's. The other components can be mounted on a punched board, located vertically to save space. The 5k pot in the low-voltage supply can be calibrated directly in volts, as suggested previously.

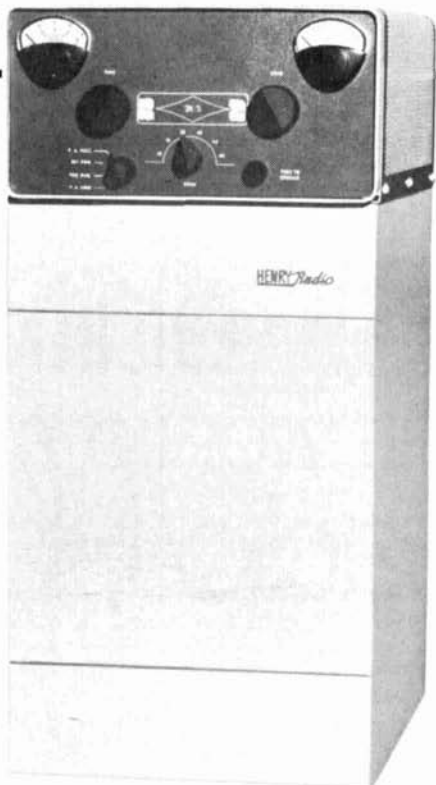
several power-supply applications. Since scr's are either on or off, it's a simple matter to determine if the regulator is working. If the regulator fails due to the scr shorting, output will rise to the maximum value.

Several output voltages may be obtained by connecting additional regulators to the rectifier outputs. The voltage-control pot may be calibrated directly in volts, eliminating the need for an output voltmeter. Changes in load current don't appreciably change output voltage. A zener across R2 (fig. 1) will provide regulation for line voltage variations.

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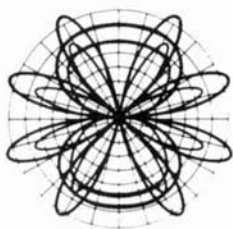
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# microwave hybrids

## and couplers

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## amateur use

Circuits borrowed from the microwave domain have many uses at the lower frequencies— here are some applications

**Microwave hybrids are extremely versatile devices.** They have many applications not necessarily restricted to the microwave region. This article explains how these circuits may be put to use at the higher amateur frequencies, where communication may be enjoyed without the interference and noise created by thousands

Henry S. Keen, W2CTK, 64 Schuyler Drive, Commack, New York 11725

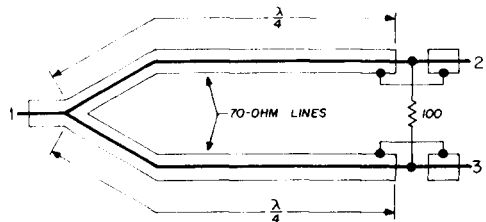
of commercial kilowatt transmitters.

When hybrids are mentioned, many hams think of bifilar-wound coils on toroidal forms. However, the circuits described here may be constructed from coaxial line for vhf or uhf use. For the higher frequencies, they may be constructed using stripline, microstrip, or waveguide techniques.

Three devices are considered:

1. The half hybrid (fig. 1). This is a degenerate form of a 4-port device that may be used as a power combiner or divider.
2. The branch directional coupler, fig. 2, which is a quadrature hybrid with some interesting applications for moonbounce work and ssb.
3. The coaxial rat race (fig. 3). Sometimes called a  $180^\circ$  hybrid, this circuit may be used as part of a balanced modulator or to match or balance two equal loads (as in combining equal sections of an antenna array).

fig. 1. The half hybrid, useful as an isolator between two power sources. Impedance at each port is 50 ohms.



## the half hybrid

This is the simplest of the devices described. It consists of a Y or T junction, two  $\frac{1}{4}$ -wave matching transformers, and a bridging resistor.

If the half hybrid is fed at port 1 (fig. 1), the signal will divide equally between ports 2 and 3. Because no phase difference exists at ports 2 and 3 when properly terminated, no voltage appears across the resistor; therefore no power is absorbed. If, however, an imbalance exists due to a mismatch, part of the signal will be absorbed by the resistor and part will be reflected to the generator. If the generator impedance is 50 ohms, it will absorb the reflected portion. The isolation between output ports is independent of the match provided by the loads.

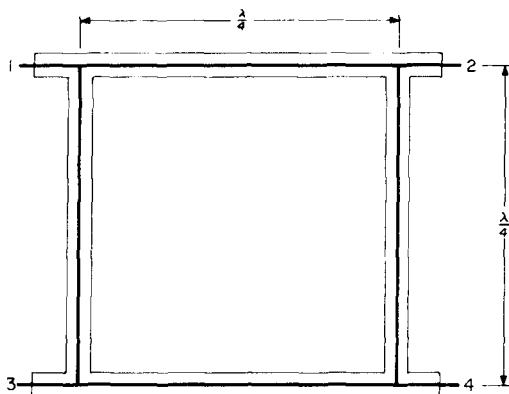


fig. 2. The branch directional coupler. This device divides power between two matched loads.

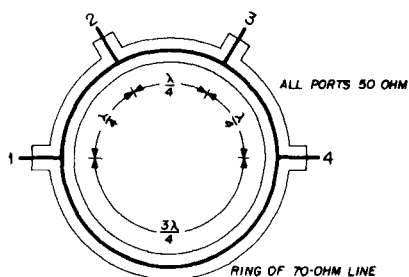


fig. 3. Coaxial rat race, or ring coupler. It can be used to balance similar sections of an antenna or as a balun.

Offhand the source of this isolation may seem vague; but if the circuit is redrawn as in fig. 4, the path from port 2 to port 3 resembles the familiar bridged-T network. In this circuit, a signal at port 2 will be nulled at port 3. Therefore, the

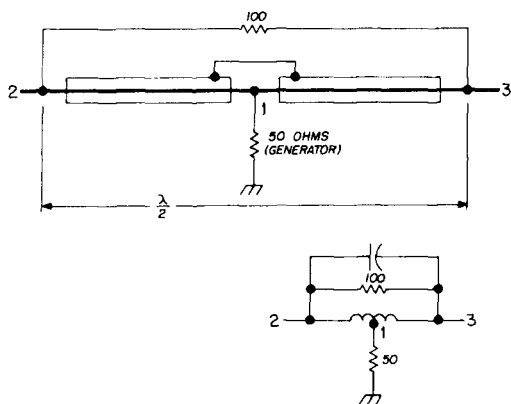


fig. 4. Equivalent circuit of the half hybrid. Note the resemblance to the bridged-T network.

load impedance at each port is not a factor in the isolation between ports.

The half hybrid may be used to provide isolation between two power sources, such as a pair of power transistors. A fail-safe arrangement is thus obtained, whereby failure of either component will not affect the load presented to the other unit. Power output will decrease by 6 dB as input power will dissipate in the bridging resistor, but loading conditions presented to the source will remain unchanged.

In applications requiring high reliability during prolonged unattended operation (as in fm repeaters), half hybrids as combining networks offer a passive means of ensuring uninterrupted service without resorting to complex switching mechanisms.

## branch coupler

The branch coupler is a 4-port device. It divides input power between two matched loads. The isolation between two input ports is a measure of the match provided by the loads. A  $90^\circ$  phase

difference exists between the signals at the two output ports, because one signal travels  $\frac{1}{4}$  wavelength farther than the other. This device can be used for sampling a portion of the signal for reference or comparison purposes.

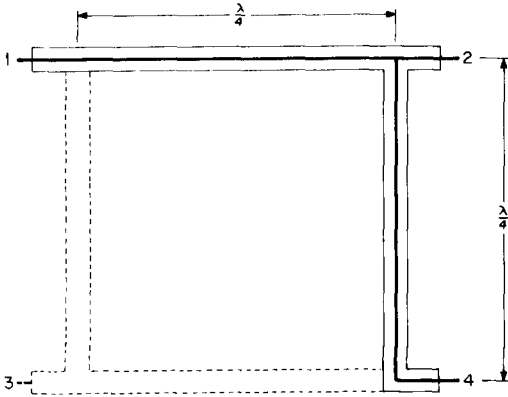


fig 5. The branch coupler. If port 3 is short-circuited, branches 1-3 and 3-4 may be removed.

**analysis**

To understand the design principles of the branch coupler, consider the case of the 3-dB version, in which the input power is divided equally between the two

branches 1-3 and 3-4 shorted  $\frac{1}{4}$ -wave stubs, shunted across ports 1-4. Thus they may be removed, leaving only branches 1-2 and 2-4.

If power is to divide equally between ports 2 and 4, port 4 must present a 50-ohm load at port 2. The characteristic impedance of branch 2-4 must therefore be 50 ohms, thus establishing an impedance of 25 ohms at port 2. In order to match this to a 50-ohm input, branch 1-2 must have a characteristic impedance of 35 ohms, which can be obtained with two 70-ohm coaxial line sections in parallel.

When the network is "reassembled," branch 1-3 will be the same as branch 2-4; while branch 3-4 will be the same as branch 1-2. For a general solution of the design, the branch impedances will be:

$$1-3 = 2-4 = \sqrt{\frac{\text{Power (2)}}{\text{Power (4)}}}$$

$$1-2 = 3-4 = \sqrt{\frac{\text{Power (2)}}{\text{Total power}}}$$

**applications**

Several applications of the branch coupler are of interest for amateur work. For example, a 3-dB coupler can be used

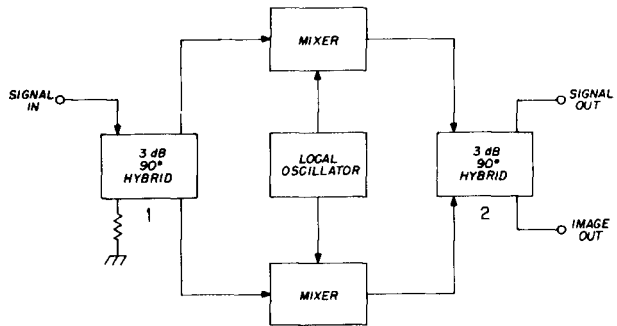


fig. 6. The branch coupler used to phase out front-end image in ssb receiver applications.

**load ports.**

In a perfectly matched coupler no signal exists at port 3, so this port can be short-circuited without affecting power distribution (fig. 5). This would make

as a phasing power divider to feed a circularly polarized antenna. Another use would be as a 90° phase shifter for phasing-type ssb generators.

Let's first consider the power divider.

If a signal fed to port 1 produces clockwise phase rotation, feeding port 3 will produce counter clockwise rotation. If both ports are fed simultaneously, linear polarization will result. A line stretcher in one of the inputs would permit adjustments to any desired phase angle.

A received signal of the same polarization as that transmitted would appear at the same port from which it was transmitted. A signal of opposite phase rotation, such as a reflected signal, would appear at the other port.

In microwave applications, isolation from 40 to 50 dB has been obtained under ideal conditions. The thought occurs that this idea might be useful for moonbounce work; however, I have no information as to how much the circular polarization would be degraded.

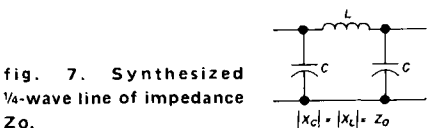


fig. 7. Synthesized  $\frac{1}{4}$ -wave line of impedance  $Z_o$ .

### single sideband

Single-sideband phasing techniques have been used in microwave receiver design to phase out the image signal. This method also offers a theoretical 3-dB reduction in front-end noise.

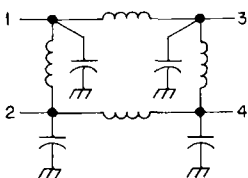


fig. 8. Lumped-constant equivalent circuit of the branch coupler.

A block diagram of such a system<sup>1</sup> is shown in fig. 6. The second 3-dB hybrid operates as a combining network designed for the intermediate frequency. Balanced mixers could be used to cancel the noise contributed by the local oscillator.

### impedance synthesizer

At lower frequencies, the branch

coupler may be synthesized with appropriate values of L and C. An equivalent  $\frac{1}{4}$ -wave line may be constructed for any desired characteristic impedance (fig. 7). The absolute values of each reactance at the design frequency should equal that of the line being synthesized. The capacitors in the final version, fig. 8, are identical in value.

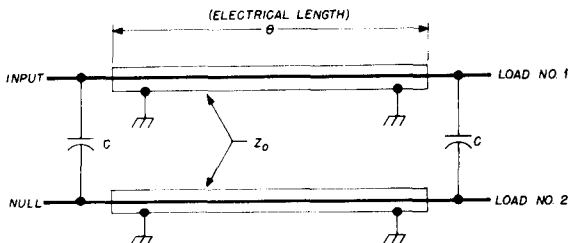


fig. 9. Capacitively-coupled hybrid is another form of the  $90^\circ$  or quadrature hybrid.

### coaxial rat race

The standard form of the 50-ohm rat race, or ring coupler, is shown in fig. 3. It consists of a closed loop of 70-ohm line with a circumference of three  $\frac{1}{2}$  wavelengths. The four ports are located  $\frac{1}{4}$  wavelength apart, with first and fourth ports connected by a  $\frac{3}{4}$ -wave line.

A signal fed to port 1 divides in two; each half travels around the loop in opposite directions. The path to port 4 is  $\frac{1}{2}$ -wavelength longer than that to port 2, so the two signals arrive at their respective loads in phase opposition. Port 3, located midway between the two loads, will therefore receive no signal. The loads must be identical for this cancellation to occur.

As a matter of interest, both loads can be removed, leaving only the loop with ports 1 and 3. Cancellation will occur at the center frequency. This dual-path structure is known as a re-entrant filter.

If the signal is fed to port 3, the two loads will be fed in phase. Any in-phase reflections of equal magnitude from ports 2 and 4 will arrive at port 1 out of phase and will therefore cancel. If the loads are unequal, and the reflected signals differ in amplitude or phase, or both, then cancel-

lation will be incomplete, causing a signal to appear at port 1. In some applications, a matched load may be placed at the odd port to absorb the imbalance.

### applications

The rat race offers an excellent means of adjusting signal balance between similar sections of an antenna array. A detec-

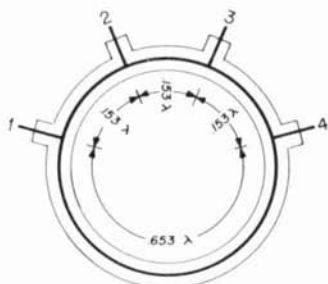


fig. 10. Coax rat race constructed with 50-ohm line.

tor-indicator, such as a receiver with an S-meter connected at port 3, would show imbalance between array sections. Identical lengths of transmission line must be used between ports 2 and 4 and their respective loads to avoid complications due to phase differences.

The rat race also functions well as a balun. When used for this application, the balanced load impedance is twice that of the coax input line, and port 3 is usually grounded.

### capacitively-coupled hybrid

The capacitively-coupled hybrid shown in fig. 9 is another form of the 90° or quadrature hybrid. Coaxial line of any convenient characteristic impedance can be used in its construction as long as the correct line length and proper coupling capacitances are used. The electrical length of the line elements is computed from:

$$\text{Coupling (dB)} = -20 \log_{10} \cos \theta$$

The reactance of the coupling capacitors is:

$$X_c = Z_0 \tan \theta$$

Thus, for a 3 dB hybrid using common

50-ohm coaxial cable, the lines would have an electrical length of 45°, and the coupling capacitors would each exhibit 50 ohms reactance.

### 50-ohm rat race

If you don't happen to have any 70-ohm line handy, you can make a rat race with 50-ohm line, which is suitable for spot frequency or narrowband work. In this version (fig. 10) ports 1 through 4 are separated by 0.153 wavelength of 50-ohm line. The long side is 0.653 wavelength, taking into account the cable's velocity factor.

At lower frequencies, the rat race is replaced by a center-tapped transformer. In the higher-frequency regions, where waveguide is used, a device known as the "magic Tee" performs the same function.<sup>2</sup>

In all regions of the radio spectrum, hybrid devices exist in one form or another, which can contribute much to the versatility of equipment design.

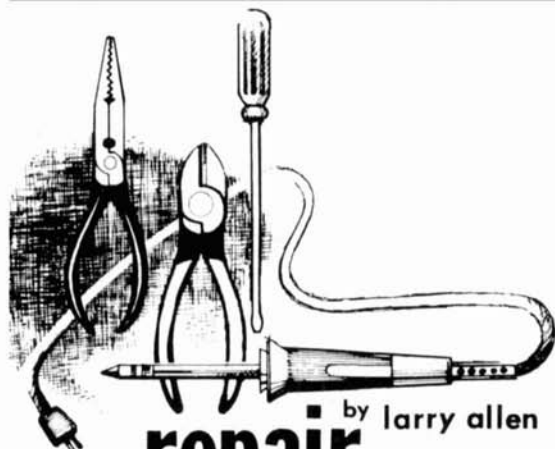
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1. M. Loss, "Phasing Unwanted Images Out of Microwave Receivers," *Electronics*, July 12, 1965.
2. Keith Henney, "Radio Engineering Handbook," Fifth Edition, McGraw-Hill, New York, p. 6-31.

ham radio



The DXer's dream.



# the repair bench

by Larry Allen

## doing your own transistor tests

To hear some guys tell it, a transistor is the easiest thing in the world to test. But others don't agree. A transistor to them is still a mystery.

Well, the truth is, most transistors can be tested without complicated equipment, gimmicks, calculations, or formulas. To keep it simple, there are just two basic things you need to find out about a transistor: (1) Does it work at all? (2) How well?

### transistor parameters

That word "parameters" scares off a lot of hams. It conjures up complicated graphs with bent lines and long formulas with Greek symbols and big and little letters. All the word actually refers to is *conditions of operation*.

One transistor manual lists 103 possible parameters. They're great for a transistor designer. But a lot fewer is plenty for testing on the repair bench. In fact, I won't even use the term "parameters." Instead I'll just tell you about the voltages, currents, and resistances that tell you how a transistor is doing.

I'll start with the diagram of a simple transistor stage in **fig. 1**. This is a grounded-emitter amplifier—probably the most common transistor stage in use today.

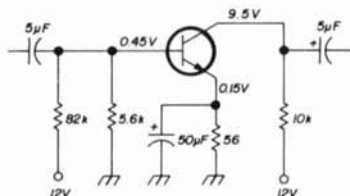
The transistor is npn. Bias is forward when the base is slightly positive with respect to emitter. The collector is "far" positive with respect to emitter.

A pnp transistor takes negative voltage on the base to forward bias the emitter-base junction. That's not necessarily a negative voltage to ground, but to emitter. The collector of a pnp operates "far" negative from the emitter.

### which way is up?

Some hams I've talked to about transistors seem confused by operating voltages. One key to understanding is knowing how to describe the voltages.

For example, in **fig. 1** if the base



**fig. 1.** Common-base transistor amplifier is popular in amateur equipment.

voltage changes to 0.1 volt, it has obviously become less positive. That means less positive with respect to wherever you're measuring from, and for most measurements that is ground.

Look at the same voltage with respect to the emitter. As it's labeled on the diagram, the base is normally more positive than the emitter by about 0.3 volt. (The emitter is 0.15 volt, and the base is 0.45 volt; between the two is 0.3 volt, the base more positive than the emitter.)

Know what that means. "More negative" is exactly the same thing as "less positive." And "more positive" means the same as "less negative."

If the base voltage in **fig. 1** drops to 0.1 volt, the voltage relationship between base and emitter changes. The difference is then 0.05 volt (0.15 minus 0.1 equals 0.05), but the base has become *less positive* than the emitter. That's the same as saying it is *more negative* than the



emitter. The emitter-to-base bias has become 0.05 volt negative. (Call it emitter-base bias, not base-emitter bias. You want the emitter as the point of reference, so name it first.) An npn transistor with the base negative is reverse-biased. Collector current can't flow.

This should make clear that, even though you measure voltages with your voltmeter common lead connected to ground, the important thing is the voltage between elements of the transistor. In most transistor stages, your chief interest is the voltage between emitter and base; of secondary interest is the voltage between emitter and collector.

Suppose someone tells you the base voltage on one of these transistors has

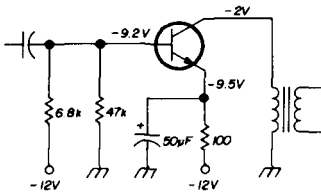


fig. 2. Changing polarity of power supply doesn't alter circuit arrangement or operation.

“gone up.” What does that really mean? Usually he means the voltage is higher in the polarity shown on the schematic.

Consider the base voltage in fig. 2. It appears “lower” than the emitter voltage. Its value is less. Measured to ground, the base voltage is less negative than the emitter voltage. The important thing is this: being less negative, the base is *more positive* than the emitter. That provides forward bias for any npn transistor.

If the base voltage goes up—that is, if it goes further negative with respect to ground, as the voltmeter measures—the bias actually decreases. Say the meter measures  $-9.4$  volts. The base has become more negative than it was. Looking from the standpoint of emitter-base bias, it tells you more if you say bias has become *less positive*. Forward bias is therefore reduced. Your voltmeter thus shows base voltage higher than before, but bias is less.

These are important relationships in transistor repair work. The simplest way to combat this seeming ambiguity is to quit using such vague notions as “up” and “down” for voltage measurements. Form the habit of thinking more negative or less negative, more positive or less positive.

### tests that reveal

At the repair bench you are usually concerned with a transistor in some piece of equipment. Tests you can make without unsoldering the transistor are the handiest.

There are three ways to evaluate a transistor in that circumstance. Two additional tests can be made if you unsoldered one or two transistor connections.

Finally, two quick test procedures evaluate a transistor outside the circuit. They are especially handy if you have a batch of unidentified transistors you want to check out. Even these tests can tell you more about transistor quality than you might expect.

### voltage measurements

Once you examine dc flow in transistor stages, you can figure out a lot from the voltages. If a voltage is wrong, deduction can tell you whether it's the transistor or something external.

Pretend the stage in fig.3 is giving you

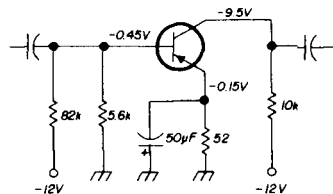


fig 3. Pnp transistor in this basic amplifier works the same as npn; only change involves voltage polarities on the various elements.

trouble. Your voltmeter tells you the base actually has  $-5$  volts on it instead of the low  $-0.45$  volt that's normal. Think out the possible causes.

Could be one of the base resistors is bad. But collector-base leakage in the

transistor is far more likely. You can verify by disconnecting the base lead of the transistor. If voltage on the open base lead is still highly negative, the transistor junction is leaky.

Or, in the same stage, suppose the emitter measures  $-0.9$  volt. For some reason, more current than normal is

The other two in-stage test ideas utilize a transistor's bias characteristic. For most transistors, zero and reverse bias cause zero collector current. A healthy forward bias assures significant collector current. These precepts of course apply only if the transistor is not defective.

The first test is for stages in which the

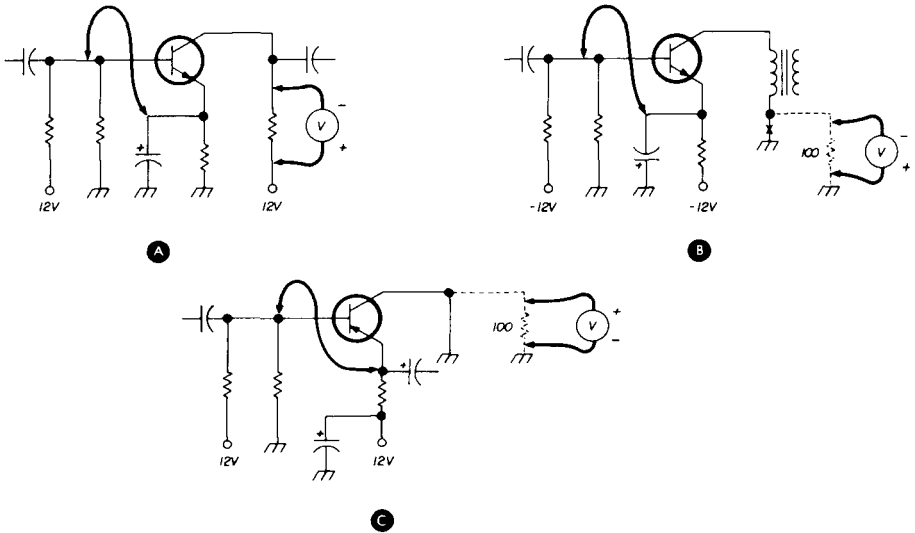


fig. 4. Voltmeter connections in several amplifier stages for making bias-change operation tests. Idea is to eliminate bias on stages that normally use forward bias and add it to those that don't, while watching the change in collector current. You can add a resistor if the collector circuit doesn't have one.

flowing in the 52-ohm resistor the emitter voltage is measured across. The transistor is probably drawing too much current.

But is that due to overbias or a transistor defect? If base voltage has remained about the same, the trouble is likely in the transistor. You see,  $-0.9$  volt at the emitter, with only  $-0.45$  volt at the base, constitutes reverse emitter-base bias for this pnp transistor. That would reduce current through the transistor, not increase it—*unless* the transistor happens to be defective.

There are plenty of other examples of this kind of reasoning. Just remember which polarity of transistor you're dealing with and the likely effects of voltage changes. And don't forget to interpret voltage measurements in terms of their relation to each other and to the transistor itself.

transistor operates with forward bias. You can determine that from the schematic. Remember, forward bias is base-positive for an npn transistor and base-negative for a pnp.

Connect your voltmeter at one of the points shown in fig. 4. Several possible connections are illustrated. If you need it, you can insert the 100-ohm resistor; its value won't bother the circuit much. Indirectly you are measuring collector current.

Notice the voltmeter reading. Then clip a shorting jumper between base and emitter. The voltmeter reading should drop to almost nothing. If it doesn't, the base isn't controlling collector current.

The second test is for stages where zero or reverse bias is normal. (The transistor may conduct, but probably during only a small portion of each signal

cycle, leaving an *average* or dc bias that is zero or reverse.) The voltmeter connections are the same as in **fig. 4**.

This time, instead of eliminating bias by shorting base to emitter, you apply a definite forward bias to base. Figure out from the schematic what would constitute forward bias for the transistor. Then somehow alter the bias to make it temporarily forward. The meter reading should take a definite move upward, signifying more collector current.

For instance, the npn transistor in **fig. 4A** has forward bias only when the base is more positive than the emitter. How do you make it more positive? One way is to reduce the value of the supply resistor, since it goes to a positive voltage source. Just bridge it with a low-enough resistance to make the base more positive than the emitter. If the transistor is working normally, the voltmeter shows more collector current.

In **fig. 4B** the basic supply scheme is different. But the transistor is still npn. Forward bias requires base to be more positive than emitter, same as always. But how can you make it that way? Just remember that more positive is the same as less negative. Bridge a lower resistance from base to ground, low enough to reduce the base voltage to a value less than at the emitter. Collector current goes up. If not, the transistor isn't responding as it should.

The transistor in **fig. 4C** is pnp. Forward bias demands a base more negative (less positive) than the emitter. It should be now be easy for you to figure how to make this base less positive. When you do, the voltmeter should register higher collector current.

### detecting abnormal leakage

Those tests let you know a transistor can control its collector current. That's the key factor. But there's another factor that can keep a transistor stage from performing up to par. You need a way to check *leakage*.

Basically, it's easy. Your voltmeter and soldering gun are the only equipment you need.

The leakage that can most upset stage operation is from collector to base. The collector junction of an operating transistor has a high reverse bias. If that junction lets "carriers" through in the wrong direction, transistor gain is poor.

To measure collector-base leakage, disconnect only the base lead of the transistor. Clip the voltmeter common lead to the emitter. Set the voltmeter as if you were measuring collector voltage. Touch the other test lead to the free end of the base lead. Voltage there should be almost nonexistent. Unwanted leakage lets current across the junction to the meter.

### testing out-of-circuit

If you have a transistor tester, fine. With a good one you can test transistors in or out of the stage faster than with the tests I've outlined here. But if you don't have one, you may often need these procedures.

Tests outside the stage are popular with hams. The basic instrument is your ohmmeter. There are two main purposes. One is identification. The other is evaluation.

Hams often pick up transistor "bargains." You get a handful of odd-lot transistors, often unmarked or marked in some way that means nothing to you. You may not know if they're pnp or npn. You might not even know which wires go to emitter, base, or collector. Here's how to settle these doubts.

An ohmmeter with 1.5 volts or less between the test leads is safest (measure with some other voltmeter). More voltage might pop a transistor junction. Also, notice which test lead has the positive voltage and which the negative; you'll need to know for these tests. Nowadays, it seems most ohmmeter batteries are connected with positive voltage on the common or black test lead.

Pick any two transistor wires. Clip the ohmmeter to them in first one direction and then the other. If you get no reading, try another pair, again measuring in both directions.

When you get a low ohms reading (150 or less), one of the ohmmeter leads is

clipped to the base wire. The way most transistors are arranged, it is the wire in the middle.

But you can make sure. Leave one ohmmeter lead clipped to the wire you think goes to the base. Move the other lead to the remaining transistor wire. If the ohmmeter reading is again low, the lead you didn't move is definitely clipped to the base. If not, the one you moved was.

You can now identify the transistor type. When you get low readings to both other elements with the positive ohmmeter lead connected to the base, you are testing an npn transistor. A pnp transistor gives low readings when the negative ohmmeter lead is clipped to the base.

You've identified the base, but you don't know which of the other two wires goes to the collector. There were clues in years past, but you can't trust the dots, stripes, and tabs on today's myriad of transistors. And basing diagrams aren't standard enough to help much either.

Start with the ohmmeter connected to show low resistance between the base and either of the other elements. You know which wire is base, so unclip that lead and move it to the other unidentified wire. The meter should read infinity, or open. If not, the transistor is defective.

Then click the range switch of your ohmmeter to higher scales until you see a slight downward meter deflection (something less than infinity). This usually happens on the Rx10k or Rx100k range. Next, reverse the two ohmmeter leads. The ohms reading will either go lower or return to the infinity end of the scale.

Connect the leads for the lower reading. Of course they are between emitter and collector. The negative ohmmeter lead is at the collector. This works for npn or pnp. Put a spot of paint or fingernail polish by the collector wire so you can identify it thereafter.

### leakage by ohmmeter

The tests you've already made tell you if a transistor is leaky or shorted. It's just a matter of interpreting.

When you've established the two low-resistance readings from the base, notice

**Two-step method for identifying transistor type and base, collector and emitter connections. You need only your ohmmeter, but the transistor should be out of the circuit.**

### ohmmeter tests

**Step 1.** Find transistor lead that measures low R (150 ohms or less) to both other leads; that is the base lead.

If the ohmmeter lead on the base goes to the . . .	negative	positive
end of your ohmmeter battery, the transistor is . . .	PNP	NPN

**Step 2.** Connect the ohmmeter for lowest R (above 10k) between the remaining transistor leads.

The negative ohmmeter lead identifies the collector

the readings in the reverse directions. If they're under 10k for either junction, there is too much leakage.

If you find low readings in both directions between any two leads, that junction is shorted. If a reading between two leads shows open both ways, even on the Rx100k scale, that junction is open.

A reading less than 10k from collector to emitter, in either direction, indicates too much leakage.

### next month

While your attention is on transistors, perhaps it's a good time to go into a complaint hams hear first from other hams. Ever been accused of putting out a distorted voice signal? It's easy for distortion to creep into speech amplifiers and you never know until someone hollers.

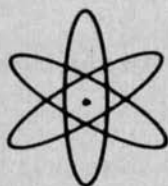
Usually the tests outlined this month spot any transistor defect that might cause distortion. But other parts in the stage can be responsible. And then there's always the oddball transistor that tests okay but goes ahead and creates distortion anyway. In my next column I'll tell some ways you can get rid of that kind of trouble.

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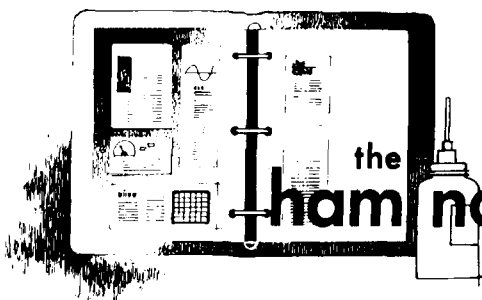
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# the ham notebook

## simple wwv receiver

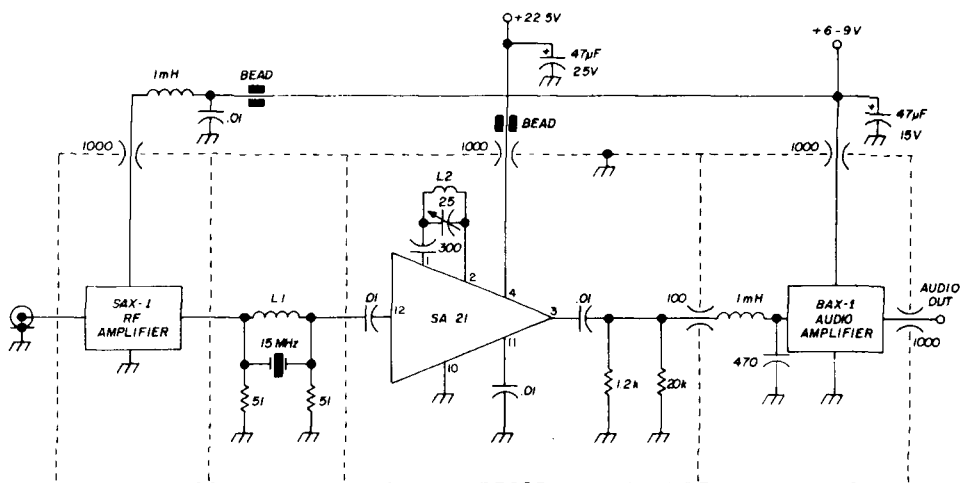
The simple fixed-tuned WWV receiver shown in **fig. 1** uses a crystal filter and an IC i-f amplifier designed by W6GXN (*ham radio*, November 1969, p. 24). Rf and audio amplification are provided by two inexpensive experimenter's modules available from the International Crystal Company. Selectivity with the crystal filter is excellent—on the order of 6 kHz—more than sufficient for reliable WWV reception.

Doug Pongrance, WA3JBN

## surplus ic's

Now that surplus digital integrated circuits are so commonplace, more and more experimenters will be using them in their circuits. Unfortunately, most of these low-cost ICs use 14-lead flat packs—with leads spaced 0.05 inch apart. This small spacing and the natural fragility of the IC makes them extremely hard to solder into a circuit.

\*The SAX-1 transistor rf amplifier is \$3.50; be sure to order the low kit (3 to 20 MHz) for this application. The BAX-1, a broadband untuned amplifier that is useful from 20 Hz to 150 MHz, is \$3.75. Order from International Crystal Mfg. Co., Inc., 10 North Lee, Oklahoma City, Oklahoma 73102.



L1 10 to 18  $\mu$ H (CTC X2060-4)

L2 3.3  $\mu$ H, 30 turns no. 26 enameled on a T44-10 core

**fig. 1.** Simple WWV receiver uses active i-f filter for selectivity. The SAX-1 and BAX-1 modules are available from the International Crystal Company.\*

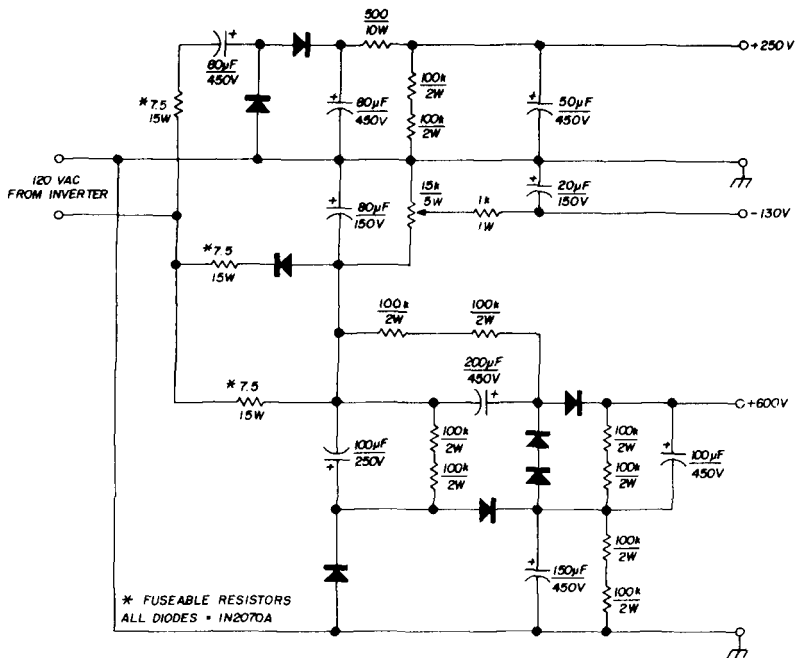


fig. 3. Low-cost mobile power supply uses mobile ac inverter.

However, I have found a simple method that works out very well. First of all, bend leads 2, 4, 6, 9, 11 and 13 down at the case at a 90° angle. Now all the leads are spaced 0.1 inch apart; much better for soldering and making circuit board connections. Bend the remaining leads down, out from the case an 1/8 inch or so.

Use the layout shown in fig. 2 for putting the ICs on a circuit board. I made a small template from a piece of aluminum, and attached it to the circuit board with a piece of Scotch tape and drilled

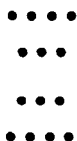


fig. 2. Full-size drill template for mounting 14-lead integrated circuits on printed-circuit board.

the holes in the board. With this much spacing it's not too difficult to draw circuit trails. You could accomplish approximately the same thing with perforated board with holes on 0.1 inch centers, but the problem here is connecting wires to the fragile IC leads. It's much easier and quicker with an etched circuit board.

Always check out the IC before you

solder it into place. It's next to impossible to remove one of these 14-lead IC's from a printed-circuit board without destroying it. Flip-flops can be tested with the output from your 100 kHz calibrator. Run a lead from the output of the IC to the receiver antenna socket; if the flip-flop is working properly you should pick up calibrate signals at the 50 kHz points on the dial. Integrated-circuit gates can be given a cursory checkout with dc levels. For more involved testing you'll need a square-wave generator and an oscilloscope.

Nat Stinnette, W4AYV

## low-cost mobile supply

Recently I wanted to try mobile operation with my Heath HW-32A, but I didn't want to invest in an expensive mobile power supply. Since I had a dc-to-ac inverter on hand, I decided to build a transformerless voltage quadrupler and doubler circuit using the inverter as the ac source. The circuit is shown in fig. 3. Output voltages are +600 volts, +250 volts and -130 volt bias.

Henry Frink, W4GEG

## surplus relays

Surplus 24-volt dc relays are often available to the amateur experimenter at attractive prices. Most of these relays are well designed (and originally very expensive), but hams tend to steer clear of them since a 24-volt dc power supply is required. Not so. I've been using these relays, powered off the ac line, for many years; not even a transformer is needed, just a silicon diode, a resistor and a filter capacitor.

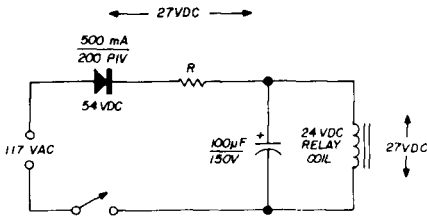


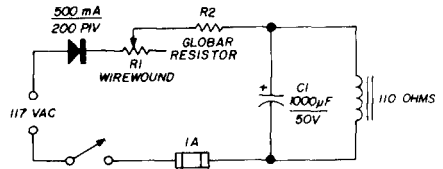
fig. 4. Operating a 24 Vdc relay from the 117 Vac line. Resistor R is a 10-watt wirewound unit, the same resistance as the relay coil.

Some of the late model hermetically-sealed relays have a relatively high resistance, but most of the open-frame types have a resistance in the range from 150 to 500 ohms. With the circuit shown in fig. 4 the dc output from the diode is 54 volts. If the resistor is chosen with the same resistance as the relay coil, 27 Vdc will be impressed across the relay. Use a 10-watt wirewound resistor. The filter capacitor only has to be large enough to keep the relay from buzzing; generally 100  $\mu$ F will be more than enough. An electrolytic rated at 150 volts costs only a few cents more than one with a 50-volt rating, and the higher rating is worthwhile in terms of trouble free operation.

You can obtain a small time delay (that is, the relay will hold in for a small time after the switch is turned off) of 1 to 2 seconds by simply increasing the filter capacitor to 500 to 1000  $\mu$ F. For this application a 50 working-volt capacitor is suitable. For longer delay periods—up to 30 seconds—use a Globar resistor in series with the coil as shown in fig. 5. I tried two different types of Globar resistors, type FR-9 and FR-50. The FR-9 is used

for replacement service in tv sets and is widely available. It works quite well with relays having 150 ohms coil resistance or less. The FR-50 works best with coils with greater than 150 ohms resistance. If you can't find an FR-50, it is interchangeable with type FR-100 and -FS-800 (type numbers by Workman Associates, the distributor).

Time delays can be roughly predetermined from fig. 5. If a relay has too high resistance for a particular application, it can be lowered by the simple



time delay	R1	
4 - 5 sec	500	FR-9
8 - 10 sec	500	FR-50
15 - 20 sec	250	FR-50
20 - 30 sec	250	FR-9

fig. 5. Time delays to expect with different Globar resistors (based on 110-ohm relay coil). Value of C1 can also be varied.

expedient of putting a composition resistor in parallel with the coil.

The opposite effect—rapid pickup—can be obtained with the circuit shown in fig. 6. The two no. 313 pilot lamps have very low resistance when cold and this permits rapid relay pickup because of the initial over-voltage. Supply voltage is reduced to normal as soon as the lamp heats up and its resistance increases. An ordinary relay in this circuit, in parallel with 60  $\mu$ F, was sufficiently responsive to follow keying at 20 words per minute.

Neil Johnson, W2OLU

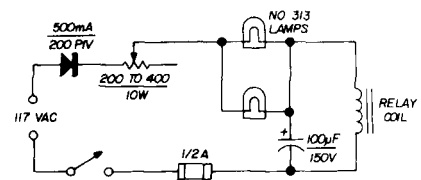


fig. 6. Rapid armature pickup occurs in this circuit because of the low cold-resistance of the lamps, allowing an initial over-voltage.



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DATE 3-11-70  
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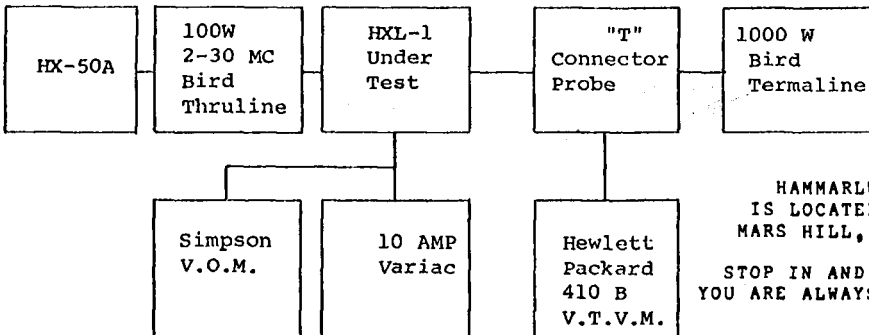
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NOTE: ADJUST LINE VOLTAGE TO 110 VOLTS UNDER LOAD FOR POWER MEASUREMENTS.

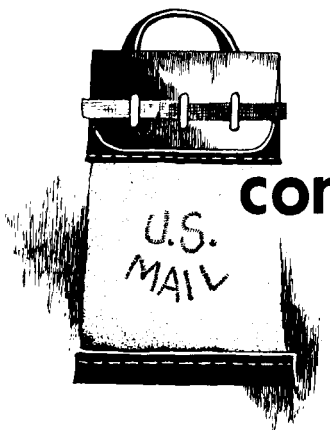
BAND FREQUENCY	RF DRIVE * * WATTS	PLATE VOLTAGE * * VOLTS	PLATE CURRENT * * MA	POWER OUTPUT * * WATTS	% EFFICIENCY * *	P.E.P. OUTPUT * * WATTS
80M 3.8 MC	100	1800	650	860	73.5	
40M 7.3MC	100	1725	600	840	81.0	
20M 14.3MC	100	1700	608	840	81.0	
15M 21.3MC	100	1600	725	810	70.0	
10M 28.3MC	95	1650	900	820	55.0	

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## comments

Dear HR:

Your comments in the January, 1970 editorial on QSL cards—a subject that will be with us to eternity! I am a keen-on-cards man, not necessarily juicy DX, but any cards, even from the next street. I QSL 100% via the bureau, and send a batch every other week, so no great delays on my part. My records show overall returns of 53%, with the U.S. returning 41%. My operation is about 95% CW on the high-frequency bands, mainly 20 and 15, so I work plenty of Yanks. Only the Novices can be relied on to QSL, and they usually want air mail, which is too expensive when you work 5 or 6 in an evening.

My rig is a Heathkit HW-100 which gives an excellent account of itself with only 80 watts input (homebrew power supply provides only 480 volts to the PA). The antenna is an end-fed 200-foot wire about 23-feet high with three bends in it, so I sigh a little when I hear this "1 kW, 3-element beam up 50 feet" stuff coming over from W-land.

George Rooney, G3MKH  
Cheshire, England

Dear HR:

I subscribed to *ham radio* without having seen a copy on the basis of the recommendation of a friend, and I was quite anxious to see what I had bought. I must say that I am delighted with the first two issues. The layout and readability are excellent, and the technical

quality is easily on a par with the best engineering publications.

I am an electronics design engineer and brought the February issue to work. Several of the engineers in my group read the article on power supplies. One engineer, a digital type, said he really had not understood power supplies before.

Around here audio and radio are analog, and since I am the only one dealing with radio I am the "analog nut"—but they still wanted to read your "analog" magazine.

W. G. Barrett, WA6ESV  
Westminster, California

## speech processing

Dear HR:

A small note concerning the speech clipper portion of Mr. Frank Jones' circuit for his phase-modulated two-meter transmitter in the February, 1970 issue: the clipping diodes, when connected to their source through a series resistor, do not act as clippers but perform a logarithmic conversion to the signal as per the article by Mr. Lee Richey, WA3FIY, on a speech processor in the January issue. The series resistor provides the constant current source needed for the log conversion. The lower value of resistance used by Jones in no way detracts from this function, other than loading the drive circuit more heavily, but allowing greater output. This is a characteristic of all common germanium diodes. (We usually use 4.7k series resistance driven by an emitter follower in this circuit.)

If large audio voltages are applied the waveform will appear to be clipped but not symmetrically, and the amount of drive needed cannot be obtained from the



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**HAM RADIO MAGAZINE**  
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circuit using the voltages shown. Thus, the audio would be logarithmically converted by this circuit and would appear to work very well with the fm circuitry shown but clipping would not normally occur.

It should also be noted in Mr. Richey's circuit that when the additional fet follower is used the gate and its bias resistor should be isolated from the diodes by a capacitor.

**W. Herbert Schiebold**  
Bloomfield Hills, Michigan

## filters for speech clipping

Dear HR:

Although there appears to be a lot of literature available on rf speech clippers, all the articles I have been able to read completely neglect the question of filters, and this is where a major problem can easily arise.

Most technical literature simply states that the second filter (following the clipper) should be similar to the first (sideband-generation filter). This sounds all right until you find that no two filters are exactly the same.

For example, in my transmitter I use a Japanese-made Kokusai 455 kHz mechanical filter ( $R_t = 10k$ ). When I went to the agent to buy a second filter for my clipper, he showed me six, all with different frequency characteristics. I chose the one which was closest to the unit in my transmitter:

	existing filter	new filter
center frequency	455.01 kHz	454.99 kHz
6-dB bandwidth	2.5 kHz	2.44 kHz
30-dB points	456.62 kHz 453.41 kHz	456.66 kHz 453.51 kHz
60-dB points	+2.4 kHz -2.1 kHz	+2.35 kHz -1.87 kHz

The effect of adding the second filter was a loss of output and the elimination of a small band of voice frequencies.

No doubt there are expensive filters available which would be satisfactory, but I doubt if amateurs could afford them. However, the solution is simple. The

second filter, while having the same center frequency as the first, should have a wider passband, and this condition is easily met on 455 kHz by using a 15k Kokusai mechanical filter. The one I have shows 6-dB bandwidth of 3.4 kHz and 60-dB bandwidth of 6.2 kHz. There is thus no detrimental effect on the signal itself, but the harmonics are eliminated and quality maintained.

Unless this question of filters is dealt with in technical discussions amateurs could be put to a lot of expense leading to unsatisfactory results when building rf speech clippers. This would be a great pity because rf clipping, properly used, gives terrific results, and all ssb exciters need it.

**Syd Hudson, ZL1AFO**  
Auckland, New Zealand

## magazine shredding

Dear HR:

I hope that you will continue to adopt a sensible policy with respect to the names of articles. I appreciate informality as much as anyone, and indeed, our magazine holds informal presentation as a cornerstone of policy. But, I agree with E. L. Foster and believe the titles of articles ought to describe the contents, however briefly. If one uses E. L. Foster's magazine-shredding technique, one has often to re-label an article with its real title, rather than the entertaining but misleading one with which it was christened. I'd also like to suggest that it is not always necessary to use "transistorized" in a title, because of the very large number of transistorized items. It may even be useful one day to use "tube-operated" instead!

**Leo Gunther, VK7RG**  
Dynnryne, Tasmania

Leo is editor of *The Australian EEB*, an informal electronic experimenter's bulletin published about eight times a year. Subscriptions are \$2.00 per year and well worth it. *The Australian EEB*, 32 Waterworks Road, Dynnryne, Tasmania 7005, Australia.



# TEN-TEC KEYERS

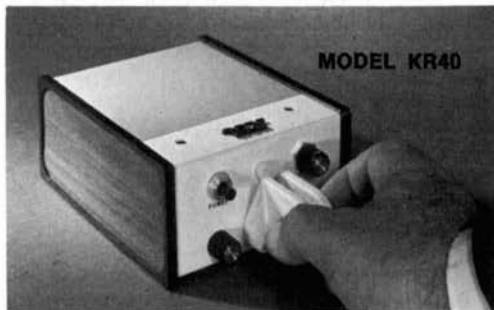
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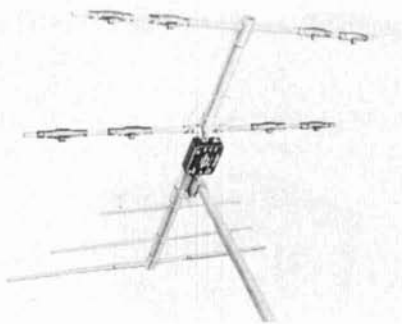
# new products

## rotary qsl file



This new rotary QSL file holds up to 500 QSL cards each in a clear plastic pocket. A turn of the knob brings each of the cards into view. Each QSL holder comes complete with 600 clear plastic pockets; refills are available to provide space for up to 500 cards. The rotary QSL holder takes up little room on the operating table, rotates on its base so it can be viewed from all sides, provides easy access and filing for your QSL cards and leaves your walls free for certificates and awards. Model CB-8-H rotary QSL file is \$8 postpaid from M-B Products & Sales, 1917 Lowell Avenue, Chicago, Illinois 60639.

## beam antennas



Telrex has just announced a complete, new line of antennas under the brand name "Challenger." These antenna systems feature a balun-fed five-element Tri-band array for operation on 10, 15 and 20 meters using a single transmission line. The antennas have a peak power rating of 1 kW. Front-to-back ratio is rated at 28 dB. Other Challenger models range from  $\frac{3}{4}$  through 80 meters. The entire Challenger line, as well as other Telrex antenna systems, are described in catalog PL70, available free by writing to Telrex Labs, Asbury Park, New Jersey 07712.

## multimeter

This new multimeter from Radio Shack is offered at a kit price but only needs a battery to be ready for use. It features 28 ranges that cover from 2 to 1200 Vdc full scale at 20,000 ohms per volt, 6 to 1200 Vac full scale at 10k ohms per volt, and 60  $\mu$ A to 300 mA full scale. Four resistance ranges cover 1 ohm to 12 megohms, and a decibel scale covers -20 to +63 dB in five ranges.

A jewelled meter movement and 1% precision resistors promise a long useful life. The mirrored scale prevents parallax errors when reading. The instrument is shipped complete with test leads, batteries and instructions. The model 22-022 multimeter is \$14.95 at your local Radio Shack, or write to Radio Shack, 730 Commonwealth Avenue, Boston, Massachusetts 02215. An accessory leather case is available for \$1.95.

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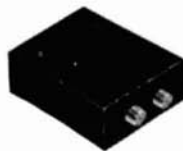
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— K1RA

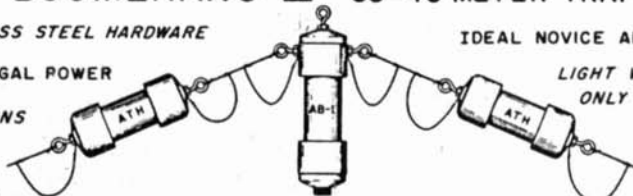
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**SING** a September song! 1970 ARRL National convention September 25-26-27, Statler-Hilton Hotel, Boston. Free brochure & discount coupon from W1VRK, 28 Forest Ave., Swampscott, Mass. 01907.

**SELL: EICO 753X** Transistor VFO, 751 AC Supply, asking \$125.00. John M. Fearon, 3384 Peachtree Rd., N.E., Atlanta, Ga. 30326.

**THE ZERO-BEATERS A.R.C.** Hamfest will be held on Sunday, August 2nd. Washington, Mo. City Park. For further information write or contact Zero-Beaters A.R.C., Box 24, Dutzow, Mo. 63342.

**MVARA HAMFEST** August 2. The Mahoning Valley Amateur Radio Assn. will sponsor a hamfest Sunday, August 2 at Lions Park, New Bedford, Pa. Located nine miles east of Youngstown, Ohio, one half mile north of US 422 on state route 932. Door prizes and flea market. Call in freq. 146.94 and 146.34 — 146.76 repeater. For information contact Frank Dodd, K8UYF.

**SPECIAL OFFER** — Ham Radio Binders regularly \$3.95 each — now three for \$10.00 postpaid. Ham Radio, Greenville, N. H. 03048.

**NORTHERN CALIFORNIA Hams:** Best deals — new and reconditioned equipment. Write or stop for free estimate. The Wireless Shop, 1305 Tennessee, Vallejo, California 94590.

**SAVE.** On all makes of new and used equipment. Write or call Bob Grimes, 89 Aspen Road, Swampscott, Massachusetts, 617-598-2530 for the gear u want at the prices u want to pay.

**IT HAS BECOME NECESSARY** to change the date of the Iowa 75 meter phone net picnic from August 9th to August 16. The picnic will be held in Marshalltown, Iowa at the Riverview Park. Festivities will begin around noon with the frequency of 3970 being monitored.

**TEKTRONIX 524D** Scope. Perfect condition — reconditioned. Best offer. S/N 6169. Contact Al. 260 Wellesley St. E., Apt. 1414, Toronto, Canada.

**CIRCUITS** for 32 electronic projects, R.F., audio and gadgetry, complete plans \$1.00. P.M. Electronics, Inc., Box 46204, Seattle, Wash. 98146. Dealer inquiries invited.

**PLYMOUTH (ENGLAND) RADIO CLUB** announces an Official Mayflower Certificate to be awarded during the period of the Mayflower Celebrations, from March, 1970 to November, 1971. Qualifications are: One QSO with GB2USA, or any THREE members of Plymouth Radio Club, or any THREE Plymouth CITY Stations; SWL's — Reports of similar nature to above. Cost of Certificate will be 2 IRC's (2/- in stamps for UK Stations). No QSL's are necessary to verify OSO's, just log extracts which will be checked at PRC. Send qualifications to A. Baker, G3KFN, 74 Travistock Road, Stoke, Plymouth, Devon., England.

**TOUCHTONE DIAL** equivalent from Denmark. Ten hutton, convertible to all twelve with data included. State color: beige or black, limited number green. 12VDC required for oscillator operation. \$16.00 postpaid USA. J. O'Brien, W6GDD, 6606 5th Street Rio Linda, CA 95673.

**TRADE 28KSR, 19, TYPING REPERFORATOR, TT/L-3.** for 28ASR. 60 cycle supply or motor for mite. David G. Flinn, 10 Graham Road West, Ithaca, N.Y. 14850.

**THE 17th ANNUAL SOUTH WESTERN MICHIGAN VHF Picnic** will be at the Allegan County Park. August 2nd, sponsored by the Van Buren County Amateur Radio Club, W8JUJ, Bangor, Michigan.

**POLICE — FIRE — AIRCRAFT — MARINE** Calls on your broadcast radio with TUNAVERTER S1. Tunable — Crystal! Brochure. Salch Company, Woodsboro HMC, Texas 78393.

**WORLD QSL BUREAU** — see ad page 91.

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■ **SEND MATERIAL TO:** Flea Market, Ham Radio, Greenville, N. H. 03048.

**NEEDED — APRIL '68** issue of Ham Radio to fill out my collection. W2FEY, R. Plue, 157 So. Main Batavia, N. Y. 14020.

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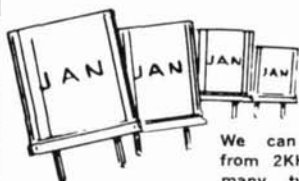
**PC BOARD.** 3/32 inch, 2 oz. Copper one side, paper base. Specify size desired. 1.5¢ per square inch plus postage. HAL Devices, Box 365H, Urbana, Illinois 61801.

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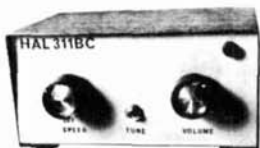
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50 KHz or 25 KHz markers to 144 MHz  
Small 1x2" G10 glass PC board  
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**WORLD RADIO's** used gear has trial-terms-guarantee! Gonset 910A - \$179.95; SR160 - \$149.95; Swan 350 - \$289.95; Swan 400/420 - \$299.95; HT40 - \$49.95; Apache - \$99.95; DX60 - \$49.95; T4X - \$319.95; HQ180AC - \$349.95; SP600JX(rack) - \$269.95; Galaxy R530 - \$649.95; 75A3 - \$209.95; Drake 2A - \$149.95. Free "blue-book" list for more. 3415 West Broadway, Council Bluffs, Iowa 51501.

**DANVILLE (ILLINOIS) HAMFEST** - sponsored by the Vermilion County Amateur Radio Association, Inc. - Date: August 30, 1970 - Douglas Park.

**THE WASHINGTON STATE HAMFEST** will be July 11th and 12th this year. This event will again be sponsored by the Radio Club of Tacoma, and will be held at the Sportsmens' Chateau, 164th and Canyon Road, south of Tacoma. Activities include CW Awards Program, QLF and QAS contests, mobile judging and mobile efficiency contests, technical meetings, technical displays, QCWA display, manufacturers' displays, 75 and 10 meter mobile hunts, swap shop, hole-in-one contest, womens' and childrens' activities, after dinner program, many fine prizes, etc., etc. Camping space available on the grounds - \$1.00 per night with free electrical hookup. 3970 KHz, 50.5 MHz, and 146.76 MHz FM will be monitored for arriving mobiles. \$5.00 includes Saturday evening dinner and registration; children under 12 \$1.50 for dinner only. Logger's breakfast served by the club Sunday for only \$1.25. Snack bar open both days. All dinner reservations must be made in advance. For information, Hamfest tickets, or motel reservations, contact John Austin, K7CZF, 8478 Eastside Drive, N.E., Tacoma, Washington 98422.

**WANTED: CUSTOMERS:** No experience necessary: Write or call "HOSS TRADER ED MOORY" for the best deal on new or used equipment: USED EQUIPMENT BARGAINS: Guaranteed: 75A-4, \$289.00; KWM-2, \$689.00; 30L-1, \$385.00; R4, \$259.00; 2B, \$165.00; Galaxy 5, \$229.00; HT-37, \$169.00; SX-111, \$99.00; NC-303, \$189.00; 260 Cygnet, \$289.00; Swan 500, \$339.00; Swan 350, \$275.00; NCX-5, \$295.00; CONTACT us for Special Deals on NEW equipment in factory sealed cartons with full factory warranty; SPECIAL Prices on New Tower and Beam Packages; TWO LOCATIONS: MOORY ELECTRONICS, Phone (501) 946-2820, P. O. Box 506, De Witt, Arkansas 72042 or MOORY ELECTRONICS, Bill Davaul (W5FQX), 415 W. 33rd, N. Little Rock, Arkansas.

**SALE:** Hammarlund HX-50a, Johnson Ranger II, Hallicrafters SX-100 all good condx. WB4AXQ, 305 Caroldale, Middletown, Ky. 40243.

**FOR SALE:** 30S-1, \$950. 75A-4 #5822, 0.5, 1.5, 2.1, spkr, \$500. Henry 2KD, \$465. 2KD-2, \$525. Squires-Sanders SS-1R, SS-1V, SS-1S, \$500. 75A4 #2408, 0.5, 2.1, 3.1, Blanka, \$400. NCL-2000, \$325. Invader-2000 (needs work), \$200. 312B-4, (new), \$165. 75S1, 32S1, 516F2, 312B4, \$700. 75S3, 32S3, 516F2, 312B4, \$1000. SW-350C, 117-XC, Shure 450, \$395. Galaxy-300, PSA-300, \$185. T4X (Drake updated 8/69), AC3, \$395. R4B, \$350. Eldico SSB-100, \$135. Heath KL-1 "Chippewa" (needs bias xformer). KS-1 p.s., \$265. Lafayette HA-410, whip, \$80. H-P 416A Ratio Meter, \$50. Prop-pitch, (converted), xformer, \$35. BC-221F, \$35. Model "B" Slicer, \$25. Kepco VR p.s., 0-1500 VDC @ 200 ma; load regulation: .005%; ripple: .001 V max, \$65. Variacs, 115V: 2 amp, \$5; 15 amp, \$25; 220 V @ 31 amp, \$50. BC-453B (converted), \$3. Constant-voltage transformer (Sola #23 25 230), 3 KVA, new, \$150. Hy-Gain Log Periodic (13-30 mcs, 5 KW), Telrex rotator/indicator/cable, \$400 (pick-up only!). Transformers, 115V: 6.3VCT @ 20 A, \$5; 25.2 @ 1 A, \$1.50; 2500/2000 VCT @ .3 A, \$10; 2880 VCT @ 5 A, \$12; 12.8 VCT @ 20 A, \$6; 1300 @ 3.0 A, \$20. Techtronix 514-D, \$165. Drake "patch", \$20. Copier, 3-M "Secretary", \$125. Eldico EE-3 keyer, paddle, \$30. TR-3, (Drake updated 11/69), MS3, AC3, Linear Systems #350-12 DC p.s., \$395. James W. Craig, W1FBG, 29 Sherburne Ave., Portsmouth, N. H. 03801. (603) 436-9062.

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T-50-2	.50	.30	.19	.45
T-37-2	.37	.21	.12	.40
T-25-2	.25	.12	.09	.30
T-12-2	.125	.06	.05	.25
Yellow "SF" Cores — 10 MHz to 90 MHz, $\mu = 8$				
T-94-6	.94	.56	.31	.95
T-80-6	.80	.50	.25	.80
T-68-6	.68	.37	.19	.65
T-50-6	.50	.30	.19	.50
T-25-6	.25	.12	.09	.35
T-12-6	.125	.06	.05	.25
Black "W" Cores — 30 MHz to 200 MHz, $\mu = 7$				
T-50-10	.50	.30	.19	.60
T-37-10	.37	.21	.12	.45
T-25-10	.25	.12	.09	.40
T-12-10	.125	.06	.05	.25

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**1970 INTERNATIONAL FIELD DAY.** The Burlington Amateur Radio Club, Inc., invites you to the 1970 INTERNATIONAL FIELD DAY to be held at THE OLD LANTERN, CHARLOTTE, VERMONT, on Saturday, AUGUST 16. Come one day early on Saturday and join the crowd with trailer, camper, or tent. Featured will be the popular flea market, net meetings, antenna raising contest, junk box amplifier contest, hidden transmitter hunt on 2FM, mobile and portable RF output contest, bingo for the ladies, door prizes and raffle drawing. Talk in frequencies include 3909, WIKOO and WIABI repeaters. Food, refreshments, and camping supplies available all day. Registration \$3.00 at the gate or send \$2.50 for early bird to Bill Fake, W1FS, 30 Southill Dr., Essex Junction, Vt. For further information write or call Bob Hall, W1DQO, General Greene Rd., Shelburne, Vt. 05482, phone 802-985-2235.

**GREENE DIPOLE CENTER INSULATOR . . . see ad** page 96, September 1969 Ham Radio.

**THE TRI-STATE AMATEUR RADIO SOCIETY** announces its Twenty-third Annual Hamfest to be held Sunday, July 12, 1970, at the 4-H Youth Rural Center on Highway 41 North. Advance registration \$1.50 and \$2.00 at the door. For details contact Jack Young, K9LAU, P. O. Box 492, Evansville, Indiana 47703.

**COMMERCIAL LICENSE EXAMS:** Second \$18.00; First \$24.00; Sample questions; Price list \$1 refundable. Ebco Enterprises, P. O. Box 432, Sparks, Nevada 89431.

**DON'T BUY QSL CARDS** from anyone until you see my free samples. Fast service. Economical prices. Little Print Shop, Box 9848, Austin, Texas 78757.

**WANTED MAY 1945 CQ.** Will trade November 1945. George Goldstone, WBAP, Northland Towers East, Southfield, Michigan 48075.

**WANT NEMS-CLARKE VHF Telemetry receiver** in any condition or parts of receivers. Gill Barber, Box 3876, No. Las Vegas, Nevada 89030.

**TELEGRAPH KEYS WANTED:** Wire, wireless. Spark or CW. Related books. Ted Dames, W2KUW, 308 Hickory St., Arlington, N. J. 07032.

**FOR SALE:** HW-12 with calibrator, \$80. HW-22, \$70. Globe King 500A (500W, a-m and CW), \$125. Gonset 913A 500-watt 6M linear, \$200. Gonset 910C 6M Sidewinder (a-m, CW and ssb) with ac and dc supplies. Laff 100W linear plus many extras, \$360. Gonset 2M 100W linear w/spare, \$265, \$90. Gonset Communicator III 6M, \$115. 6M Ameco Preamp, \$10. Eico 720 90W CW transmitter, \$55. Tecraft 6M converter with supply (7-11 MHz out), \$35. Knight R-100A gen'l coverage receiver, \$60. Heath vfo VF-1, 10-160M, \$15. Eico 23-channel CB transceiver, \$75. Heath HX-30 6M transmitter (a-m, CW and SSB), \$140. Heath HA-20 175W 6M linear, \$110. Factory-sealed Ameco PT preamp, \$55. Heath Sixer, w/crystals and mike, \$35. Ameco 6M converter with power supply, \$15. Swan 14C dc module, \$50. Drake factory-sealed DC-4 12 Vdc supply, \$105. Factory-sealed Ameco OCMW monitor, \$12. Westcom noise blander for Swan 250, \$20. Gonset 6M G-50, \$160. Ham-M rotator, \$105. Factory-sealed 24-hour Pennwood clock, \$14. All items fob. Tom Dittrich, WB2LZD, 605 Broad St., Endicott, N. Y. 13760.

**ANNUAL HAMFEST** of the Champlain Valley Amateur Radio Club will be held on July 19 starting at 10:30 a.m. EDT, at the club shack on the Akey Road, Cadyville, N. Y. (7.2 miles west of Plattsburgh on Route 3). Food and beverages available on the grounds, talk-in on 146.34-146.94 FM (WIKOO) and 3925 KC. SSB. Send advance registrations (\$1.50) to CVARC, Box 241, Cadyville, N. Y. 12918. Fun and prizes for all ages.

**TOROIDS 44 and 88 mhy.** Unpotted, 5 for \$1.50 ppd. W. Weinschenker, Box 353, Irwin, Pa. 15642.

**FOR SALE — HY GAIN TH4 \$50.00.** Henry Ingwersen, Topsfield, MA 01983.

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3B24	4-125/4D21
3B28	
4-250/5D22	4CX3000A/8169
4-400A/8438	4CX5000A/8170
4-1000A/8166	4CX5000R/8170W
4X150A	4CX10,000/8171
4CX250B	4X150G/8172
4CX250R/7580W	4PR60A or B
4CX300	4PR (any digits)
4CX350A/8321	5-125B/4E27A
4CX1000A/8168	
5R4WGB	304TL
6BL6	VA (all types)
6BM6 or 6A	250TH
6L6	450TH
7D21	450TL
8D21	QK (all types)
9C21	715C
9C25	802
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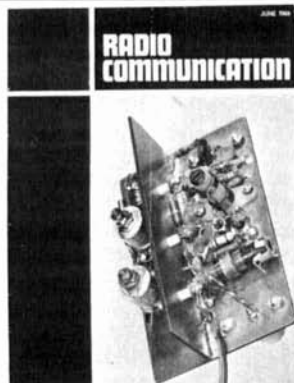
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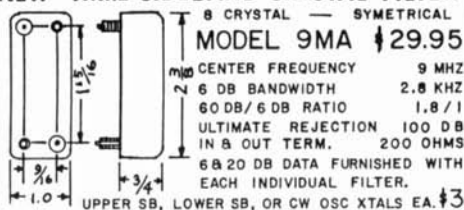
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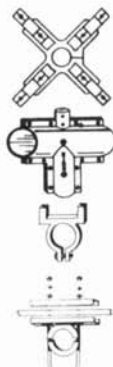
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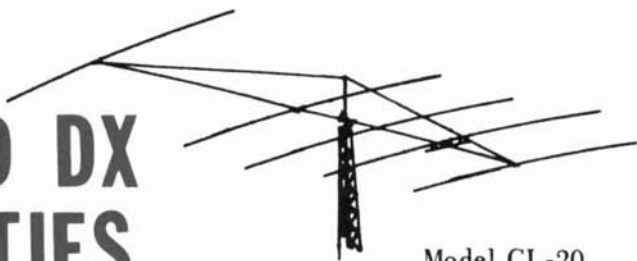
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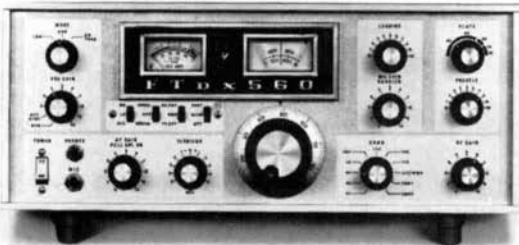
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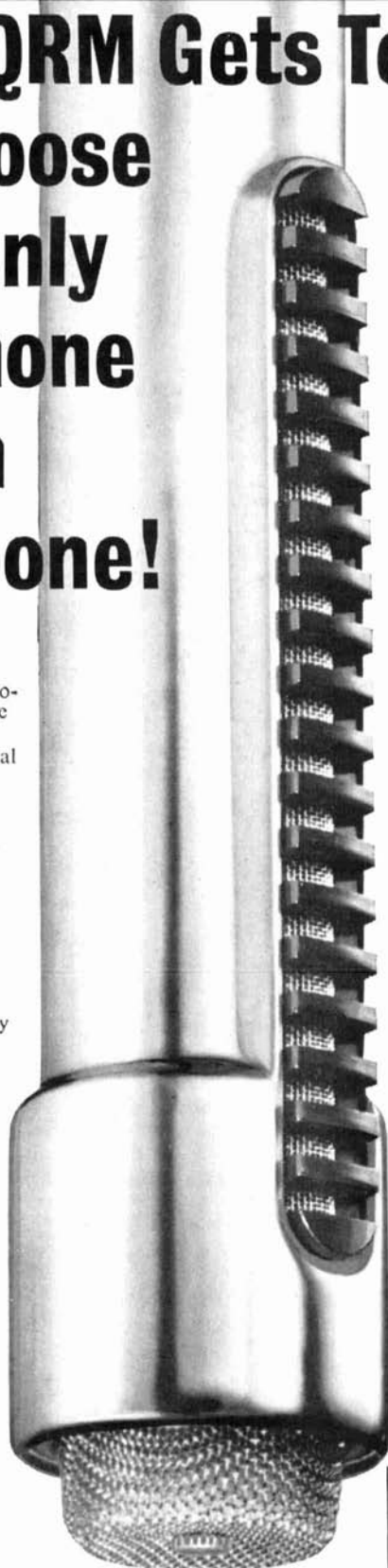
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